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Mountain Gardening

A Joint Publication of Denver Botanic Gardens
and Vail Alpine Garden Foundation

INTRODUCTION

Gardening with Altitude

The higher elevations of the Rocky Mountain West have experienced phenomenal population growth in recent decades, and all indications are that the trend will continue. Hillsides and valleys near some popular mountain communities have begun to resemble the sprawling suburban developments that surround our western cities.

As homes are built and mountain "neighborhoods" created, many owners express the logical desire for landscaping to surround and beautify their residences. But what style of garden is appropriate in a mountain setting? What kinds of plants will grow here?

The answers to these questions vary as much as the horticulturists who try to answer them. In recent years, some individuals have constructed extensive and elaborate mountain gardens which rival the best private gardens anywhere in the world; yet some individuals advocate that we should leave the mountain setting alone, and appreciate its natural beauty. For most mountain residents, the answer seems to lie somewhere in between.

Perhaps the best way to get started is to answer some basic questions:
- How much time are you willing to spend installing and maintaining your garden and landscape?
- How long is the growing season where you live?
- When does your snow cover begin and end?
- Do you want to attract or deter wildlife?
- Do you want to frame or block views from your residence?
- What is the general climate or habitat around your residence?
- Does the landscape you envision require an irrigation system?

Mountain Gardening should provoke consideration of these and other questions. This publication will focus on the unique horticultural concerns of Rocky Mountain residents who live in the foothills or mountains at elevations of 6000 feet and higher.

The authors of this anthology represent a broad range of philosophies regarding high-altitude landscaping. We hope you'll gain insight from their experience and points of view. High-altitude horticulture is rapidly forming its own identity as the regional mountain population burgeons. Dig in and create your own version of a mountain garden — we're all sharing in the development of a new horticultural tradition throughout one of the most scenic regions on earth.

Special thanks to the Stanley Smith Horticultural Trust, the Vail Valley Foundation and the Scientific and Cultural Facilities District for assistance in financing this publication.

Richard H. Daley
Executive Director
Denver Botanic Gardens

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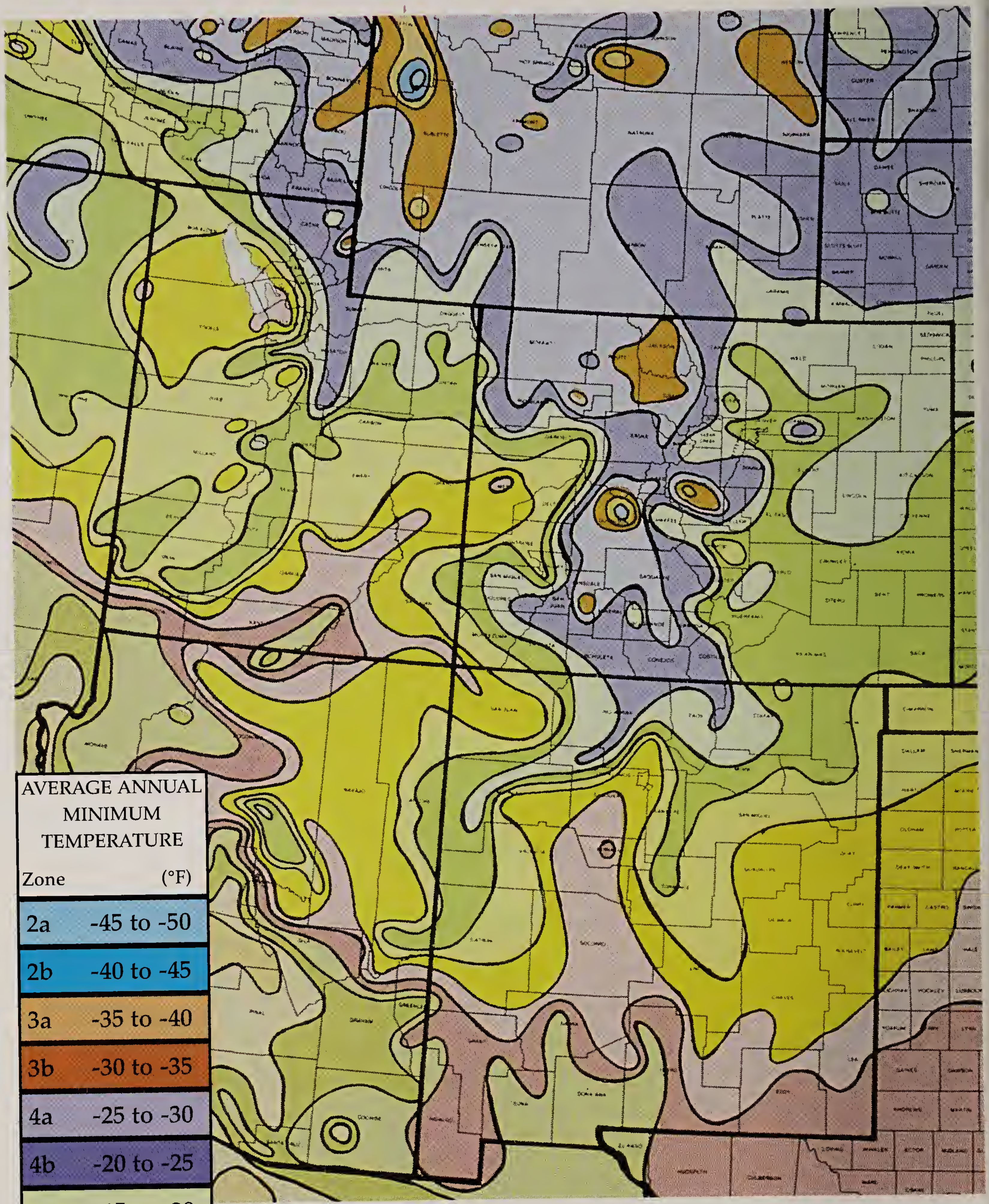
USDA PLANT HARDINESS ZONE MAP



AVERAGE ANNUAL MINIMUM TEMPERATURE

Zone	(°F)
2a	-45 to -50
2b	-40 to -45
3a	-35 to -40
3b	-30 to -35
4a	-25 to -30
4b	-20 to -25
5a	-15 to -20
5b	-10 to -15
6a	-5 to -10
6b	0 to -5
7a	5 to 0
7b	10 to 5

This portion of the United States Department of Agriculture Plant Hardiness Zone Map represents the Rocky Mountain region.

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To Fellow Mountain Residents and Gardeners:

Gardening is an important way for us to appreciate, preserve and learn more about the environment around us. I hope you will enjoy, and put to use, this fine collaboration between Denver Botanic Gardens and the Vail Alpine Garden Foundation.

Betty Ford

Betty Ford
Former First Lady of the United States

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Inside covers photo: Mountain meadow by Richard H. Daley.

Denver Botanic Gardens and Chatfield Arboretum are established and maintained by Denver Botanic Gardens, Inc. for the people of the City and County of Denver and the general public in cooperation with the Denver Parks and Recreation Department. Denver Botanic Gardens is grateful for funds from the Scientific and Cultural Facilities District (SCFD) which enable the Gardens to expand services and enhance the quality of programs and exhibits.

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Denver Botanic Gardens offers an oasis in an urban setting. Located just east of downtown, Denver Botanic Gardens is recognized not only for its beautiful gardens, but for ongoing research in plant conservation, educational programs, and many community activities including the annual Plant and Book Sale, BirdHaus Display, community gardens, summer concerts, strolls and the Blossoms of Light winter holiday celebration.

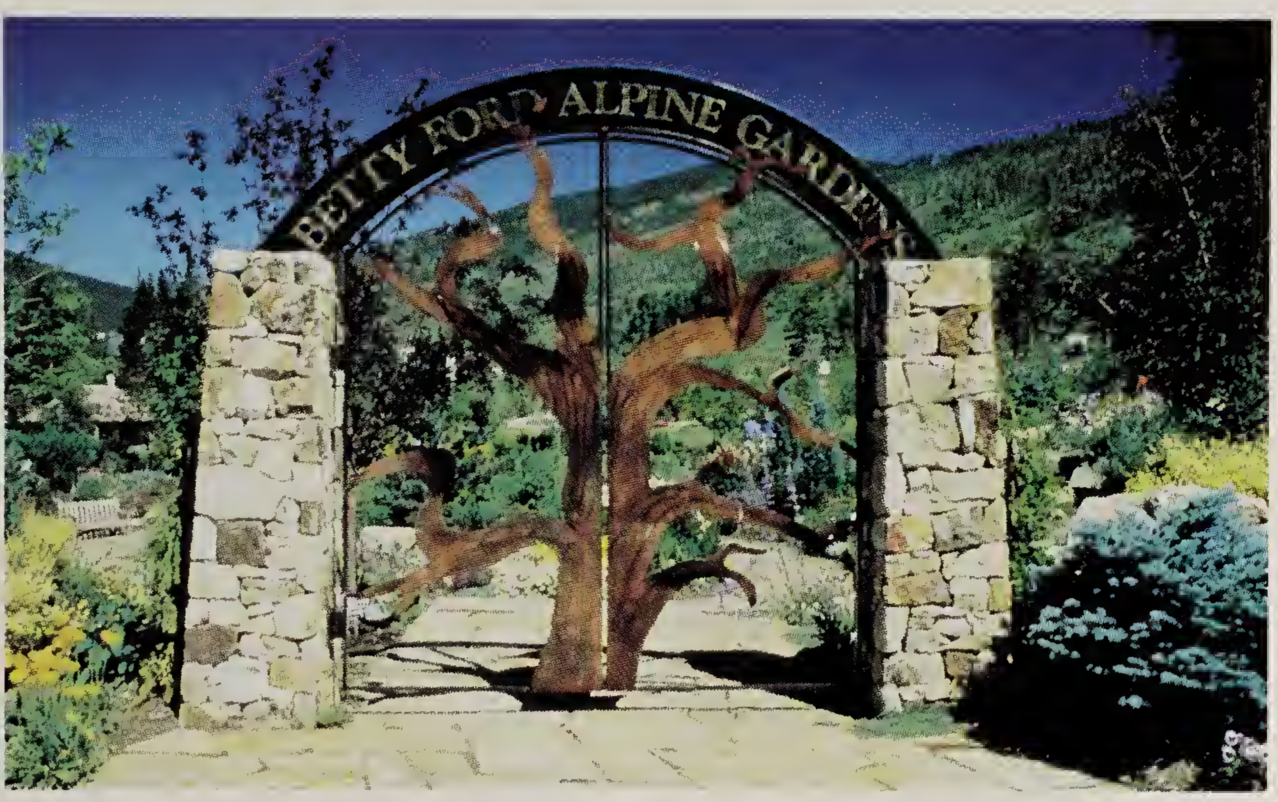
Inside, the Boettcher Memorial Conservatory houses tropical plants, flowering orchids and bromeliads. Visitors can also attend lectures year-round, educational sessions and classes led by local, national and international horticultural experts.

Outside, on 23 acres, visitors can see the world-renowned Rock Alpine Garden or stroll through the Japanese, Water, Herb, Vegetable, Scripture or Water-Smart Gardens. A new Perennial Walk displays colorful flower and foliage combinations from spring to fall and features intriguing textures year-round. The newest addition, the Romantic Gardens, features a cottage style garden with fragrant plants, a waterway, pool and waterfall and tranquil relaxation areas.

The gift shop offers books, gifts, live plants and decorative items. The Helen Fowler Library is the largest horticultural library west of the Mississippi and offers an extensive collection of horticultural books and catalogs. Seasonal special events are planned throughout the year.

Denver Botanic Gardens also manages Chatfield Arboretum, located in southwest Denver. The Arboretum's 700 acres encompass several distinct high plains ecosystems including native flora and fauna, a woodland river, wetlands, open grassland and a historic 1866 homestead farmhouse. The Walter S. Reed property at an altitude of 7,650 feet near Evergreen, Colorado and the Walter M. Pesman trail at Mount Goliath, elevation 11,500 to 12,150 feet, are managed by DBG as well.

Bristlecone pine at the Mt. Goliath site.



The Betty Ford Alpine Gardens entrance.

The Vail Alpine Garden Foundation seeks to cultivate harmony between plants and people in our mountain environment and is a horticultural pioneer in teaching and celebrating the value of plants to human life. The Foundation provides unique educational and environmental programs, encourages community beautification and plant research, and creates and maintains the Betty Ford Alpine Gardens in Ford Park of Vail, Colorado.

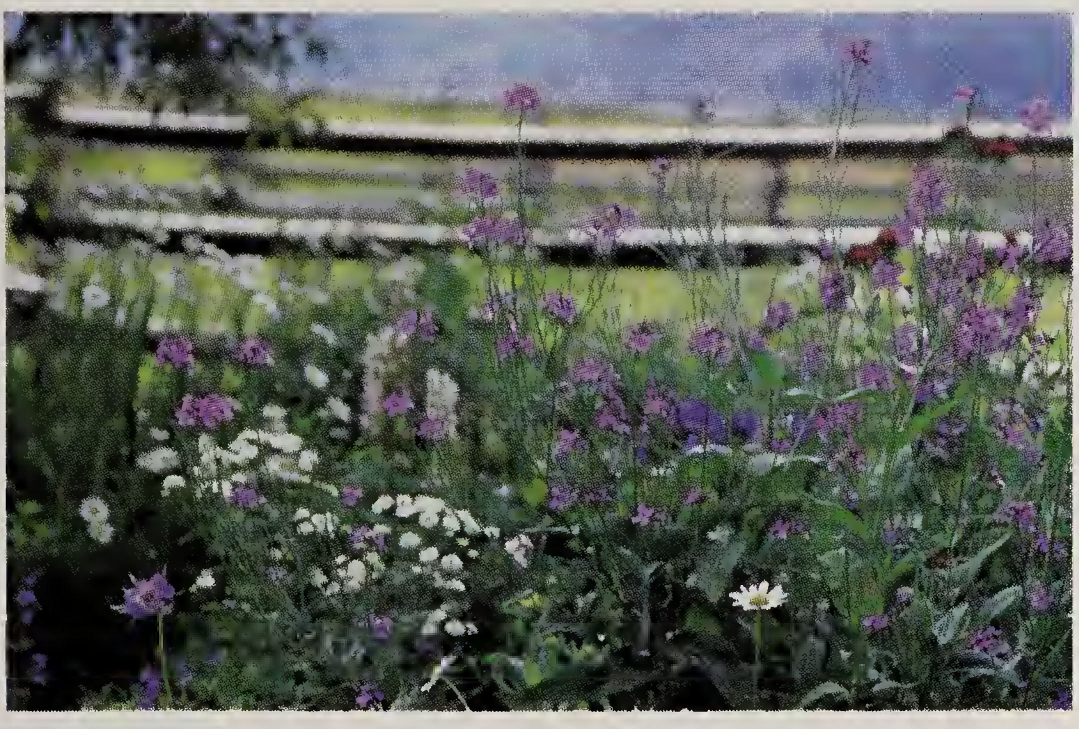
At 8,200 feet, the Betty Ford Alpine Gardens is the highest public botanic garden in North America. The Gardens, a living museum of plant collections, currently consist of three distinct and separate gardens featuring more than 2,000 varieties of plants. These gardens and remarkable outdoor classrooms, are the Alpine Display Garden, the Perennial Garden and the Mountain Meditation Garden. A fourth garden, the Alpine Rock Garden is scheduled for completion by the year 2000. This garden will feature plants native to the North American Rocky Mountains and other alpine areas from around the world. The Alpine Rock Garden will be both dramatic and intimate, consisting of several microclimates, astounding rock work and water features to inspire and delight.

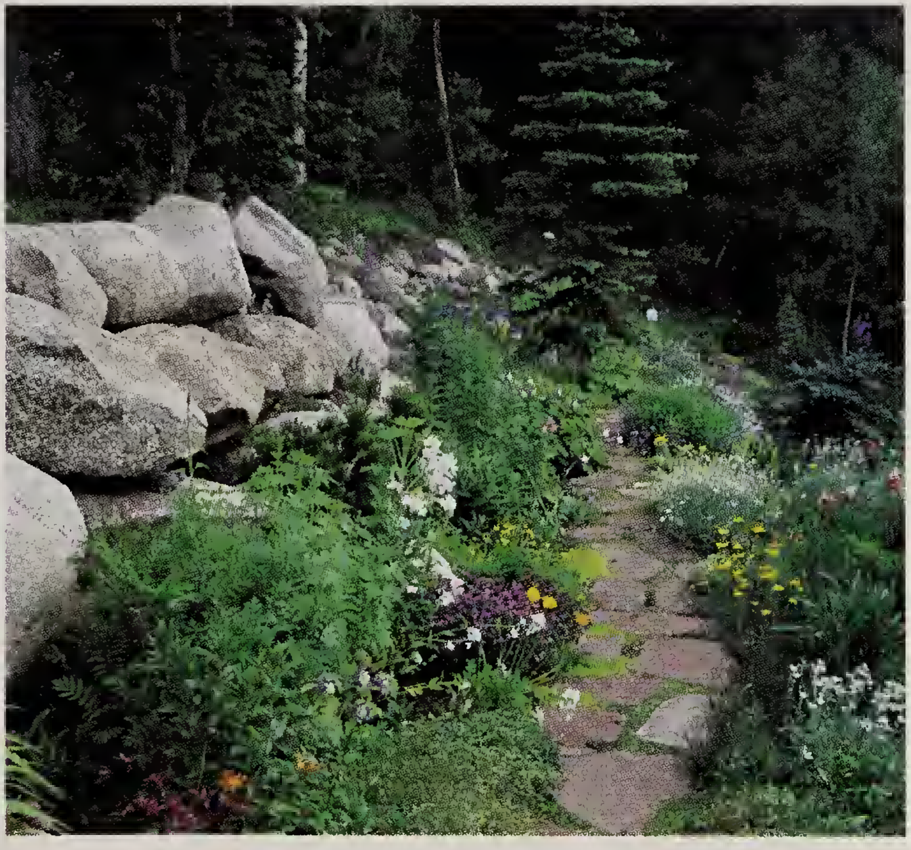
Visitors to the Betty Ford Alpine Gardens now exceed 100,000 per season — between May and October. The Gardens are open, free to the public, from dawn to dusk, snowmelt to snowfall. For information on programs, events and tours, please call 970-476-0103.

We look forward to meeting you in the Gardens!

MOUNTAIN GARDEN PICTORIAL

By Rob Proctor





AUTHOR BIOGRAPHY

Rob Proctor is a noted author, teacher and artist. He is an instructor in Denver Botanic Gardens' popular School of Botanical Illustration.

CHALLENGES IN FOOTHILLS GARDENING

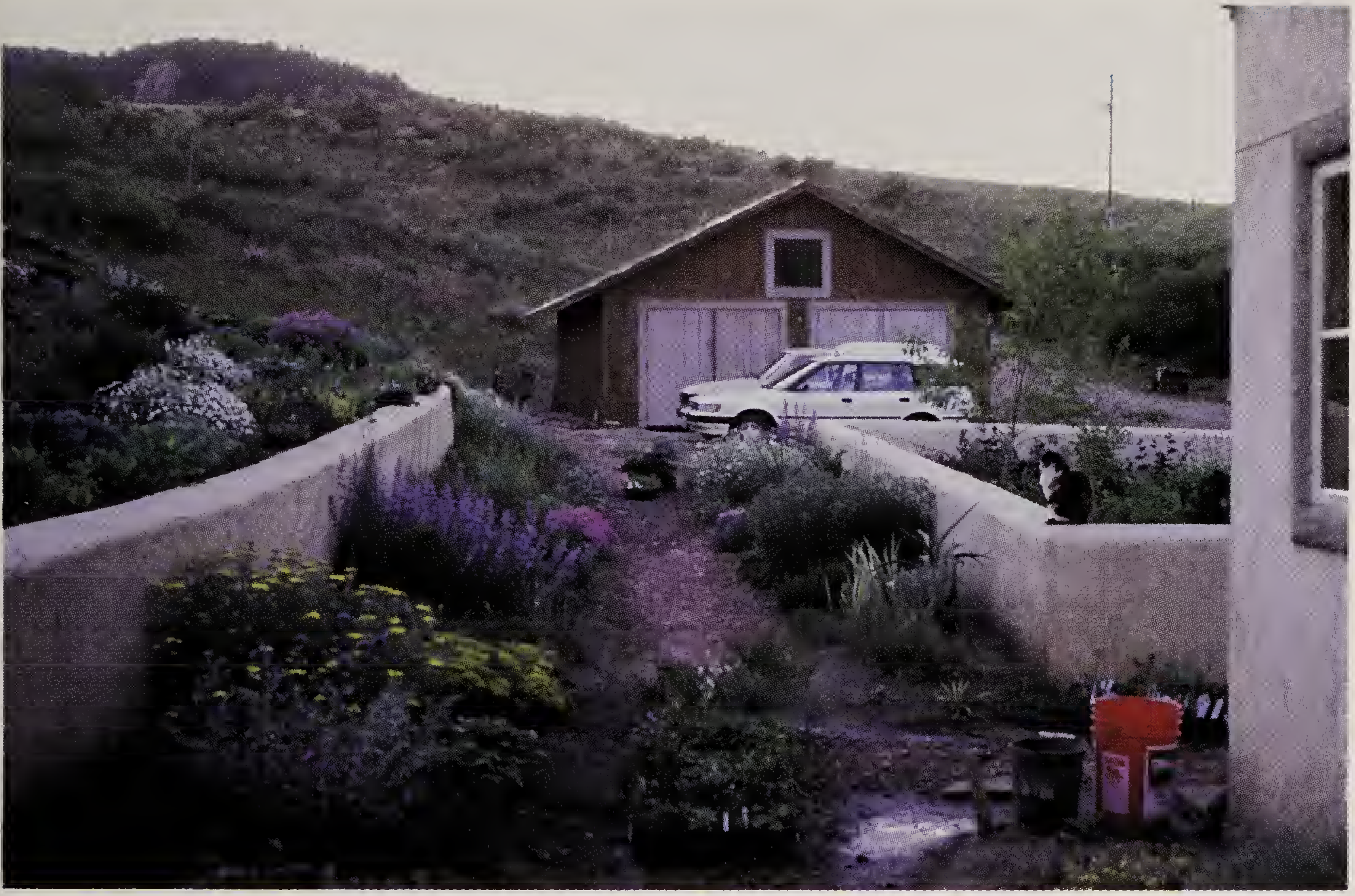
Moving one's "Eden" 1400 feet upward to an elevation of 6,200 feet, and several acres outward, didn't seem like such a big change at first. It was my dream... unlimited space, no neighbors, and inspiring natural beauty all around. Instead of blocking views, now I could celebrate them. Walking the land, I questioned how one could possibly improve on the wonderful rocks and plant communities already there. I came away feeling that my creation, no matter how gorgeous, would somehow be a crime against the perfection of the place. Luckily, this dilemma was solved by the excavators, who made such a mess around our house site that my hand was desperately needed to heal the wounds inflicted on the land. My garden space had been decided by a bunch of machines.

I wanted to echo nature. Surprisingly, this decision became my biggest design challenge. Naturalistic planting is much more difficult to do well than more formal types, and I am still working on integrating the design into the natural landscape after almost three years. My best advice to new mountain gardeners is to consider a framework to surround your creation. This makes that transition easier, be it a stone or stucco wall, a split rail fence, a tall but inconspicuous post-and-wire ranch fence or what have you. The lines between nature and the planting are now defined, and no matter whether you decide to do a billowing English-style flower border, a natural-looking informal planting of natives or something in between, having a visual boundary will help tremendously. It's also a chance to create some evocative structure, and an opportunity to make a barrier against potentially pesky garden invaders, be they rabbits, deer, range cattle, elk, rattlesnakes, or, as in our case, all the above plus two horses and four rambunctious dogs.

Deciding what kind of framework to use and where to put it depends on several things. First, how big a garden do you want? I went with approximately four acres, of which only one is actually planted, but I left some contingency space for when I have more time as my three children get older. With a big area, certain materials are going to be out of the question unless you have unlimited financial resources.

Another thing to consider is whether you want the framework to echo the house and be a dominant architectural feature, or whether you'd like to have a more low-key, meld-into-the-background kind of thing. I combined both ideas, going with a utilitarian livestock fence of wooden posts and wire around the perimeter, and within that space, making another

By Lauren Springer



The stucco walls at Lauren's new garden. *photo: Lauren Springer*

enclosure of about 80′ x 80′ with a three and a half foot stucco wall. This became a courtyard garden for my least natural plantings, and the walls keep these from clashing with the wilder parts of the garden.

The stucco also visually connects the garden with the house. I dissolved into tears upon seeing our house after the stucco had been put on. During framing and sheathing it looked awful but I assumed all that would be rectified once the stucco went on. Well, once stuccoed, the house looked terrific but completely out of place. I had worked so hard to choose colors from the predominant natural palette of the surroundings, painstakingly matching stucco samples with dried grass, juniper foliage, soil, rocks and the like. And here, after all this, the small house still looked like a land-locked barge marooned on our hillside. Building the stucco-walled courtyard completely changed this: now the site has a connection with the house.

Then the really awful work set in. It took the better part of a year and a half before I felt the garden was ready for planting. People kept asking how the new garden was coming along and when they could come see it, and I kept getting more depressed. Starting a garden in a natural site and attempting to salvage the damage done on the

A transitional wall at a garden near Vail. *photo: Ken Slump*

post-atomic holocaust that is a new construction site are a far cry from suburban or town garden creation.

The gentle art of gardening becomes an oxymoron. This was more like war. My husband enjoyed all the large rental machinery, including bobcats, to move large boulders, tractors to fix drainage problems and hydraulic-powered rototillers to break up compacted soil and reincorporate the topsoil we had removed and stockpiled during construction.

Formerly quite the organic gardener, I made an about-face and pulled out the chemical arsenal to go after the Canada thistle. After three growing seasons of spraying at monthly intervals, the weed is on the wane, but I have no illusions of ever eradicating it entirely, with decades of seeds stored in the soil and flocks of gold finches bringing new seeds from other parts of the canyon.

Last year I finally was able to indulge myself in the joys of planting. All the work had paid off — the soil was now a heavy but healthy, rich, dark clay, easy to dig when not wet. However, the foothills winds made establishing plants much harder. I've found that planting small perennials later than early September results in tremendous losses due to desiccation.

Winter protection? All those evergreen boughs scrounged after Christmas and painstakingly placed over young plants were blown down the gulch a few nights later. Forget any mulch except rock. And expect things to take longer to get settled in and grow to any size. Of course, high mountain gardens have much more snow, wonderful for plants and miserable for humans. Here in the foothills we get just a little more snow than the plains, and the season is only slightly shorter. Our temperatures are actually milder and more even. Plants emerge slowly in the spring so we rarely have frost damage.

While I am eaten alive by envy when flatland gardening friends describe all the spring things in bloom while my place is still dressed in boring tans and browns, I get to boast how many things still look good in mid and late summer when the plains take their turn at those colors. Cloudy afternoons with gentle sprinkles keep summers delightfully cool and plants happy. Everything blooms for much longer. It is fun to invent combinations never possible at 4800 feet. And though I will have to wait a few extra years before the garden looks the way I envision it, I can always turn to the natural Garden of Eden all around me for beauty and solace when my own creation isn't up to snuff.

AUTHOR BIOGRAPHY

Lauren Springer is a well-known writer, lecturer and garden designer. She became nationally recognized for her daring, unconventional approach to gardening, chronicled in her award-winning book *The Undaunted Garden*. Her new garden is well underway on 115 acres in the foothills west of Fort Collins, CO.

Before we consider style we must develop three attributes which gardening books do not list but which do affect our approach, especially at this altitude; a sense of humor and patience, an ability to accept failure, and a facility to accept being humbled by the elements. If you do not share all the attributes listed above, join us anyway and by gardening at high altitude, you will be forced to build these admirable qualities. Mountain gardeners become pragmatic and reflective not by choice but by necessity.

There is a fourth attribute, affecting our "style," which has been overshadowed by our adoration of the "English garden," especially where flower gardening is concerned. This attribute is the ability to develop confidence in our own approach rather than trying to be something that we are not. Nature is a cruel teacher and we can only be thwarted if we persist with grandiose plans to have Giverny in the rugged Tetons or below the cliffs of Grand Junction! There is much that is inspiring in our own western mountain landscape and we can develop our own style from its examples.

Remember that Giverny, Kew, Hidcote and the great gardens of Northern Europe do not contend with low rainfall, huge ranges in temperature, high raking winds, alkaline soils, searing sun in July and August, frost in May, again in September and snow at any time! These adversities would be enough to deter most gardeners but mountain gardeners are dogged folk and our gardens have their own glories.

There is much for us to learn from what grows in our mountain meadows, our sage brush flats and our cottonwood-lined river beds. However, while design can be guided by what we see in the mountains, our style or method of presentation is controlled by our own personalities and our approach to the different challenges that a garden site might offer. Life

Alchemilla vulgaris, Lobelia erinus *cv. and* Viola *x* wittrockiana *cv.* *photo: Rob Proctor*

By Angela Foster

and landscape here are more informal than many places and most rugged individuals residing here have an endearing quirkiness about them; these traits are reflected in our gardens.

One gardener might solve the problem of a steep slope by building tidy retained beds. Another might seed the whole slope in tangled spreading wildflowers. A third might use rocks or stone slabs while a fourth might add a scarecrow. All could be perceived as great "style." Each approach is right for that gardener and that is the secret. Style is not dictated by, nor gained from "style gurus." Style comes from our own interpretation and invention. There is nothing wrong with using a few books for ideas but the fun is in adding our own interpretation to them.

My approach is drawn from what I see on wilderness walks or in parks: the natural placement of rocks; twisted, gnarled scrub oak or juniper; and the variations in slope.

These natural elements are then combined in my garden with flowers in color combinations that I like and which grow here! The soft gray of the bigleaf western sage *(Artemisia tridentata)* and yellow tickseed *(Coreopsis lanceolata)* of our wilderness are reflected in my garden by English lavender *(Lavandula angustifolia)* and moonbeam coreopsis *(Coreopsis verticillata* 'Moonbeam'*)*. Johnny jump ups *(Viola tricolor)* peep out of rocky arrangements just as violets (*Viola* spp.) do in the shaded wild. At the same time, I love my splashy perfumed lilies *(Lilium* hybrids*)*, oversized delphinium (*Delphinium* hybrids) and sprawling daylilies (*Hemerocallis* cvs.). Remember too that our gardens, like the landscape, are enhanced by foliage, rocks and trees which set the stage for the flowering plants.

Dianthus *sp.*, Papaver nudicaule *and* Heuchera sanguinea. *photo: Rob Proctor*

The mountain garden can reflect our regional landscape and, like the English cottage garden, is one of experimentation, not controlled form. It succeeds when the plants grown are similar to the native plants. The cottage garden style was developed by cottager wives who added wild hedgerow plants to their vegetable gardens. While there are no hedgerows for us here, do consider the palette (from magenta through yellow, blue and red) that our own mountain meadows offer us.

We can grow perennial flower gardens of soft colors in the spring when the light is soft and cool, and

A colorful mountain garden of an informal style. *photo: Rob Proctor*

then, just as the meadow flowers change, the vivid hues of our other perennials will bloom to agree with the hot summer sun. The delicate colors of Monet's water garden paintings simply cannot exist under our brilliant western sun.

Color is a personal preference and some gardeners go to extremes. Eleanor Perenyi, in her book, *Green Thoughts*, says, "It follows that blue and white are the choices of the discriminating and your real garden snob will go so far as to cast whole gardens in one or the other." Read her book, she is wicked and gives you a good chance to laugh at yourself.

Some gardens may be defined by a fence or property line, for others the garden is backed by the natural landscape; both are elements which affected the cottage garden. Different approaches are called for in different situations and yet they can both offer an informal cottage garden feel. In a fenced garden I like to use native shrubs and lilacs against the fence to add variety in height and fullness and provide the backbone for a mixture of perennials of all different sizes and styles. For the garden which meets the natural world it is important to pay attention to the transition zone between the two, to honor each by gradually adjusting the plantings so that cultivated varieties blend with their native cousins.

Style is yours to develop within the confines of our rugged climate and landscape. It is a rewarding challenge.

Here's a basic list of the perennial survivors that bloom throughout the gardening season at 7,000 feet in Colorado.

Early Spring

Arabis caucasica — rock cress
Geum coccineum 'Werner Arends' — Werner Arends geum
Iberis sempervirens — perennial candytuft
Primula spp. and cvs. — primroses

May to June

Alchemilla mollis — lady's mantle
Aquilegia cvs. — columbines
Convallaria majalis — lily of the valley
Dianthus 'Tiny Rubies' — Tiny Rubies dianthus
Dicentra spectabilis — bleeding heart
Galium odoratum — sweet woodruff
Geranium 'Johnson's Blue' — Johnson's Blue geranium
Iris pallida — sweet iris
Iris sibirica — Siberian iris
Lupinus 'Russell Hybrids' — Russell Hybrids lupine
Papaver orientale — Oriental poppy
Phlox subulata 'Emerald Blue' — Emerald Blue creeping phlox
Polemonium caeruleum — Jacob's ladder
Pulmonaria angustifolia — lungwort
Trollius europaeus — globeflower
Vinca minor — periwinkle

July and August

Achillea 'Moonshine' — Moonshine yarrow
Aconitum napellus — monkshood
Alcea rosea — hollyhock
Campanula carpatica 'Blue Clips' — Blue Clips Carpathian bellflower
Coreopsis verticillata 'Moonbeam' — Moonbeam coreopsis
Crocosmia 'Lucifer' — Lucifer crocosmia
Delphinium cvs. — delphiniums
Digitalis purpurea — foxglove
Gaillardia x *grandiflora* — blanket flower
Hemerocallis cvs. — daylilies
Heuchera sanguinea — coral bells
Hosta cvs. — plantain lilies/hostas
Lavandula angustifolia — English lavender
Leucanthemum x *superbum* — Shasta daisy
Lilium spp. and cvs. — lilies
Linum perenne — perennial flax
Lychnis chalcedonica — Maltese cross
Myrrhis odorata — sweet cicely
Nepeta x *faassenii* — blue catmint
Paeonia cvs. — peonies
Penstemon spp. and cvs. — beardtongues
Phlox paniculata — garden phlox
Prunella 'Pink Loveliness' — Pink Loveliness self-heal
Scabiosa caucasica — pincushion flower
Verbascum chaixii — mullein
Veronica spicata — spike speedwell

End of August into September

Anemone x *hybrida* — Japanese anemone
Colchicum autumnale — autumn crocus
Lilium lancifolium — tiger lily
Perovskia atriplicifolia — Russian sage

AUTHOR BIOGRAPHY

A rugged, 28-year resident of the Roaring Fork Valley in Colorado, Foster was born in England and is now proud to be a Rocky Mountain American tending to a small 100-year old farm property. She also serves as an educational advisor in Denver and a "sometime" Gardening Editor to *The Aspen Times*. Foster's mountain garden was recently in *Garden Design* magazine.

CONSIDER NATIVES FOR YOUR MOUNTAIN GARDEN

The gardening strategy most often practiced by even professional gardeners is the trial and error or shotgun approach of spending a lot of money to acquire a profusion of plants from around the world, then throwing them at the ground in hopes that some will stick. When this doesn't work or work well enough, more effort is expended in changing the environment with rocks, boulders, soil amendments, fertilizers and supplemental irrigation in hopes that more plants might survive. The more patient or conservative gardener's benefit is to learn of the professional's failures through books, lectures, articles and over-the-fence chats.

This time honored, grueling and expensive test of will vs. environment need not be the *de facto* strategy. Instead, accept a new challenge by asking new questions. Instead of asking "will it grow?" ask yourself "should I grow it?"

Why ask this question? You are now gardening or are attempting to do so in a landscape that has taken over 10,000 years to create. Do you really believe that you can do better? Your landscape and its supporting cast of forests, shrubs, wild flowers, wildlife and grand vistas are undoubtedly reasons for your moving here. Is it really necessary to change all or part of this so that you can feel "at home?" Do you really need to plant something that requires special soils, supplemental irrigation or fertilizer? Do you want plants that might turn into weeds and not support wildlife just so that you can say that you have succeeded in growing something? Miles upon miles of roadways and thousands of acres of ski slopes, homesites, walkways, patios and commercial building sites already have eliminated much of the original landscape. Do you really need to remove more land from nature?

Instead, let Nature be your guide. Use her plants, soils and weather. Study your site and other undisturbed sites nearby with similar elevation, slope angle, aspect or compass bearing, soils and exposure to sun or shade. Soon you will notice a pattern to the landscape, a common sense dictated by thousands of years of sorting out the many species native to the Rocky Mountains. In their proper place, no native plant needs any supplemental irrigation, fertilizer, unique soil or special care of any kind.

Paying attention to that pattern, you will notice that at lower elevations Colorado blue spruce (*Picea pungens*) occupies only sites next to streams and that the more than 100 cultivars, mostly silvery-blue in color, occur rarely. Few, if any of these horticultural quirks look natural in a native landscape. The same can be said for those cultivars

By Jim Borland

Penstemons brighten a dry spot. *photo: Ken Slump*

of shrubby cinquefoil (*Potentilla fruticosa*) with anything but yellow flowers and tightly shaped Rocky Mountain juniper (*Juniperus scopulorum*) cultivars.

You will also note that aspens (*Populus tremuloides*) don't occur everywhere, but favor northern slopes or draws where soils are cool and moist. Planting aspen trees for shade or as a foil to the hot afternoon sun and ignoring their root requirements predisposes them to problems.

Provenance, a plant's nativity or origin, is linked to its genetic makeup which cannot be seen. In essence, this genetic makeup dictates how well a plant or group of plants of a single species will perform under a unique set of climatic and soil conditions, unaided by man. When planted too far outside the conditions under which many generations of the species evolved, they are destined for failure.

Typically, horticulture has moved plants from high elevations to lower ones with relative impunity because growing seasons are longer, winters are warmer and supplemental water is provided. Moving plants in the opposite direction or from more southerly latitudes poses new problems for gardeners. Foresters in Idaho, for example, will not plant ponderosa pine (*Pinus ponderosa*) seedlings more than 600 feet higher or lower than the original source of the seed.

The classic search for ironclad plants unaffected by deer, elk, gophers, birds, insects and disease often results in plants that take advantage of their invincibility and turn into weeds. A short list of invincible garden flowers proven to be weedy and problematic are loosestrife (*Lythrum* spp.), Mayweed chamomile (*Anthemis cotula*), ox-eye daisy (*Leucanthemum vulgare*), Dame's rocket (*Hesperis matronalis*), chicory (*Cichorium intybus*), common tansy (*Tanacetum vulgare*), creeping bellflower (*Campanula rapunculoides*), myrtle spurge (*Euphorbia myrsinites*), bouncing bet (*Saponaria officinalis*), bladder campion (*Silene cucubalus*), St. Johnswort (*Hypericum perforatum*), cypress spurge (*Euphorbia cyparissias*) and common toadflax (*Linaria vulgaris*). These and others will spread beyond the garden and begin, plant by plant, to displace the natives.

Fire, the fastest actor in the mountain theater, not only changes the landscape quickly, but contrarily ensures that the full diversity of plant life is maintained. Without fire, the natural pattern gradually shifts to one of relative monotony where dense forests take over meadows, close in riparian zones, force out aspens and generally shade out most other species. Because the complexities of this topic are vast, consult with your state forest service for assistance in this area. The same consultation should also help protect landscape values against loss due to dwarf mistletoe (*Arceuthobium* spp.), bark and needle insects, and declining aspens and shrub communities due to old age. Without fire, it is up to man to ensure that this diversity is not lost.

Natives for Cultivation at High Altitudes

All plants native to the immediate vicinity of your proposed garden are suitable for cultivation. Learn first how nature has successfully dealt with your proposed garden area for thousands of years, without the aid of man, before attempting to "improve" upon it. In return, you may end up with a landscape filled with plants that require little maintenance, are attractive and look like they belong and support the native wildlife.

In many cases, you may choose to further enhance your area with local natives. There are many colorful and low maintenance options that you should consider. Grasses are an important but frequently overlooked group of garden plants and the region has many suitable native grasses from which to choose. Most of these are good candidates for meadow plantings or unmowed lawns. A few can be integrated into plantings of ornamentals to be enjoyed for their form and texture.

Following are native grasses that should be considered:

Andropogon gerardii — big bluestem
Bouteloua gracilis — blue grama
Calamagrostis canadensis — Canadian reed-grass
Danthonia parryi — Parry oat grass
Deschampsia caespitosa — tufted hair grass
Festuca arizonica — Arizona fescue
Festuca idahoensis — Idaho fescue
Koeleria macrantha — Junegrass
Muhlenbergia montana — mountain muhly
Poa agassizensis — native bluegrass

Contact your local National Resources Conservation Service office, formerly known as Soil Conservation Service, with questions regarding growth habit or plant and seed availability of native grasses.

Koeleria macrantha *photo: Ed Spence*

The following wildflower natives are low maintenance options that can add spectacular color and interest to many foothills and mountain environments:

Achillea lanulosa — yarrow
Antennaria parvifolia — pussy-toes
Arnica cordifolia — heart-leaved arnica
Aster laevis — smooth aster
Balsamorhiza sagittata — balsam root
Campanula rotundifolia — common harebell
Delphinium nuttallianum — Nutall's delphinium
Dugaldia hoopesii — orange sneezeweed
Epilobium angustifolium — fireweed
Erigeron speciosus —blue aspen daisy
Gaillardia aristata — blanket flower
Geranium caespitosum — wild geranium
Mirabilis multiflora — showy four o'clock
Thalictrum fendleri — meadow rue
Wyethia amplexicaulis — mule's ears

Please refer to the "Woody Plants for Mountain Gardening" article to learn more about tree and shrub options.

When attempting to enhance your area with new natives, ask, beg and demand that these plants be made available from your plant supplier. Grow your own or combine efforts with others in your area

Grasses, perennials and adapted shrubs provide a naturalistic setting for a mountain home.

to collect seeds or cuttings and make arrangements with a grower to supply these plants for your group.

Living in a relatively unspoiled environment imposes a higher degree of sensitivity to the landscape than that practiced by most at lower elevations. Let that sensitivity extend to your garden as well.

AUTHOR BIOGRAPHY

Jim Borland is an author, radio talk-show host (KEZW 1430-AM) and Open Space Coordinator for Genesee Foundation. His experience includes plant propagation at Denver Botanic Gardens and managing a native plant nursery and a horticultural research center (at Colorado State University). Borland is an avid gardener specializing in western native plants and small fruits.

photo: Ken Slump

PERENNIALS FOR THE MOUNTAINS

Create garden impact with vivid floral color. *photo: Rob Proctor*

With proper plant selection, a mountain perennial garden can be the envy of any lowland gardener. The short summers result in a concentrated blooming season with perennial flower combinations not typically seen at lower altitudes where flowering times don't overlap. The higher level of precipitation typical of mountain climates also increases the variety of perennials that can be grown without a lot of additional irrigation. As an added bonus, the intensity of sunlight at high altitudes also intensifies flower pigments creating a virtual color riot in your garden.

For the purposes of this article, areas of the Rocky Mountain region above 6,500 feet in elevation are considered to be part of the mountain gardening arena. As you move further north, the equivalent conditions occur at lower elevations including both foothills and mountain habitats.

By David Salman

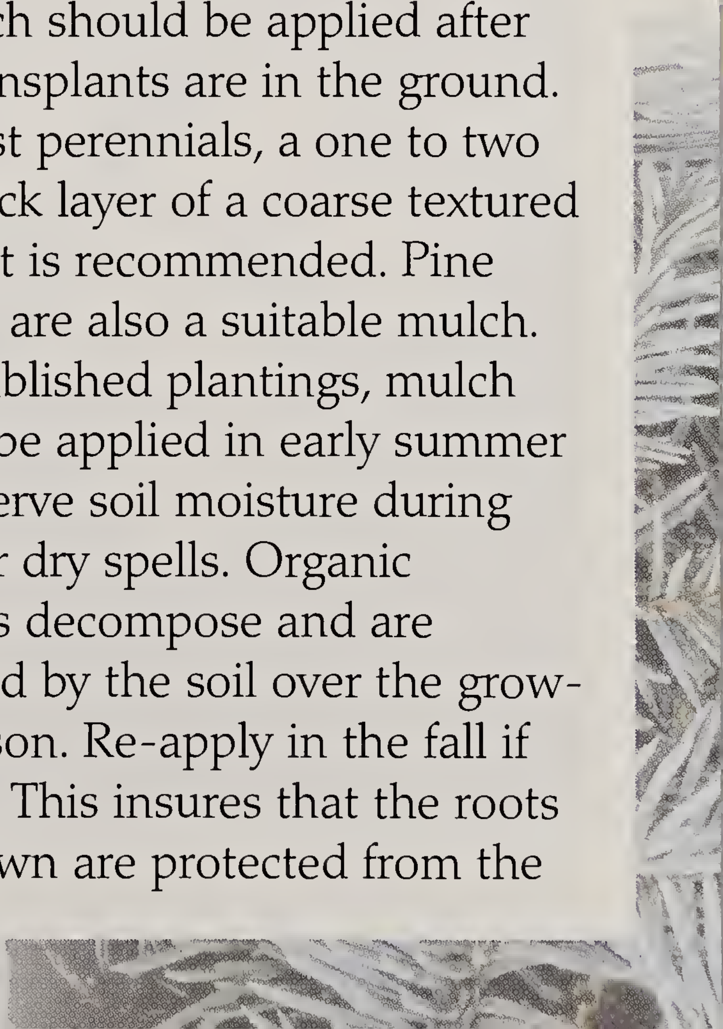
Within this mountain arena, four basic types of sites can be identified. The dry hillside, particularly in foothills locations, is often suited to rock gardens. The wooded garden requires plants suited to shady locations (see"Creating a Mountain Shade Garden"). The open meadow shares its plant palette and informal style with the cottage garden (see "Mountain Garden Style"). The fourth type of garden site is the streamside or damp meadow. When planning gardens for these different habitats, it is key that the cultural requirements of the perennial match its garden site.

Cold temperatures are the dominant climatic variable with which mountain plants must contend. When choosing perennials for the mountain garden, several factors should be considered. Winter's low temperatures affect a plant's ability to survive. In general, plants that are cold hardy to USDA Zone 4 (-20°F to -30°F) should be selected. Although, in warmer, more protected microclimates (such as flower beds against the sides of buildings or areas with winter-long snow cover), USDA Zone 5 (-10°F to -20°F) plants will also be successful.

The short summer growing season also dictates plant choices. Frosts in late spring and early summer will trouble some perennials whose flowers are frost sensitive (e.g. peony). Conversely, early fall frosts preclude use of late fall blooming perennials (e.g. Maximilian sunflower). Perennials native to areas with long, hot summers are also not generally recommended in mountain gardens. The lack of summer heat, in combination with cold nights and potential summer frosts, may result in poor garden performance.

Soil preparation and mulching are of utmost importance when planting a perennial garden. Soil improvement should be done before the planting begins. The key ingredients to creating a healthy, nutrient rich garden soil include ample compost, phosphate (soft rock phosphate is an excellent organic source), and a trace mineral fertilizer, known in organic gardening circles as"rock dust." Dig or till these additives into the soil to a depth of 12-15 inches.

Mulch should be applied after new transplants are in the ground. For most perennials, a one to two inch thick layer of a coarse textured compost is recommended. Pine needles are also a suitable mulch. For established plantings, mulch should be applied in early summer to conserve soil moisture during summer dry spells. Organic mulches decompose and are absorbed by the soil over the growing season. Re-apply in the fall if needed. This insures that the roots and crown are protected from the



winter cold. For rock gardens, a one to two inch layer of 3/8″ to 1/2″ diameter crushed gravel mulch is best. Gravel mulch keeps the crowns of the plants dry during the spring thaw, holds heat around the plants in the summer and encourages many rock garden species to re-seed and spread.

Sunny hillside settings are well suited to rock gardening. These sites typically have dry, well drained soil conditions. The Rock Alpine Garden at Denver Botanic Gardens and the Betty Ford Alpine Gardens in Vail are two fine examples of how this gardening style reaches its greatest potential in the intermountain West.

Erigeron '*Grand Ridge*' *photo: High Country Gardens*

Here are a few of the vast numbers of native and adapted species that can be used in the rock garden:

Acantholimon spp. — prickly thrifts
Aethionema schistosum — stone cress
Anntenaria parvifolia 'McClintock' — McClintock dwarf pussy-toes
Armeria maritima — sea pink
Aster alpinus — alpine aster
Aubrieta 'Whitewell Gem' — Whitewell Gem aubretia
Aurinia saxatilis — basket of gold
Delosperma spp. — hardy ice plants
Dianthus 'Rose Dawn' — Rose Dawn garden pink
Erigeron compositus 'Grand Ridge' — Grand Ridge fleabane
Gentiana septemfida — gentian
Iberis sempervirens 'Little Gem' — Little Gem dwarf candytuft
Linum flavum 'Compactum' — dwarf golden flax
Penstemon spp. — beardtongues
Phlox subulata — creeping phlox
Saponaria caespitosa — alpine soapwort
Saxifraga spp. and cvs. — saxifrages
Thymus serpyllum var. *minus* — creeping thyme
Veronica oltensis — thyme-leaf speedwell
Zauschneria garrettii 'Orange Carpet'— Orange Carpet hummingbird trumpet

The stream-side and damp meadow site demands a more specialized plant that will thrive in wet soils. Most of these flowering perennials are highly attractive to butterflies. The grasses and sedges are nicely ornamental, adding wonderful textures and colorful fall foliage to the landscape. They are also highly valued for stabilizing streambanks and preventing erosion. The groundcover, Canada anemone, a white-flowered buttercup, is also recommended for this use.

(Thanks to Neil Diboll, Prairie Nursery of Westfield, Wisconsin, for suggestions regarding wetland/ streamside plants.)

Following are some desirable wildflowers, grasses and sedges to beautify these wet areas:

Flowering Perennials

Asclepias incarnata — swamp milkweed
Dodecatheon jeffreyi — Sierra shooting star
Eupatorium maculatum — Joe Pye weed
Gentiana andrewsii — bottle gentian
Iris missouriensis — western blue flag
Iris sibirica — Siberian iris
Lobelia siphilitica — blue cardinal flower
Monarda fistulosa — mountain bee balm
Primula parryi — Parry's primula
Rudbeckia laciniata — cutleaf coneflower
Smilacina stellata — false Solomon's seal
Thalictrum dasycarpum — purple meadow rue
Verbena hastata — American blue vervain
Veronicastrum virginicum — Culver's root

Groundcover
Anemone canadensis — Canada anemone

Grasses and Sedges
Carex hystericina — porcupine sedge
Carex vulpina — fox sedge
Glyceria striata — fowl manna grass
Spartina pectinata — prairie cordgrass

Moisture-loving plants at a damp garden site. *photo: Ken Slump*

AUTHOR BIOGRAPHY
David Salman is co-founder of Santa Fe Greenhouses, Inc. and its mail order division, High Country Gardens, Santa Fe, NM. He is a 1979 graduate of Colorado State University with a degree in horticultural science. As president and chief horticulturist of the company, he oversees all aspects of the greenhouse, nursery and mail order divisions.

Shade gardening at higher elevation requires creativity beyond the norm due to the limitation of color caused by a severe lack of hardy plant material. This in turn creates a significant challenge for gardeners in their search for suitable specimens since in all probability, most of the shade plants that gardeners fancy are not hardy in the colder parts of USDA Zone 4 (-20°F to -30°F) into Zone 3 (-30°F to -40°F). Lessons can be learned from the nearby natural habitat but they can lead to pitfalls. After all, don't assume that just because the tall chiming bells (*Mertensia ciliata*) grows in damp shady locales, that its lovely close relative Virginia bluebells (*M. virginica*) will as well.

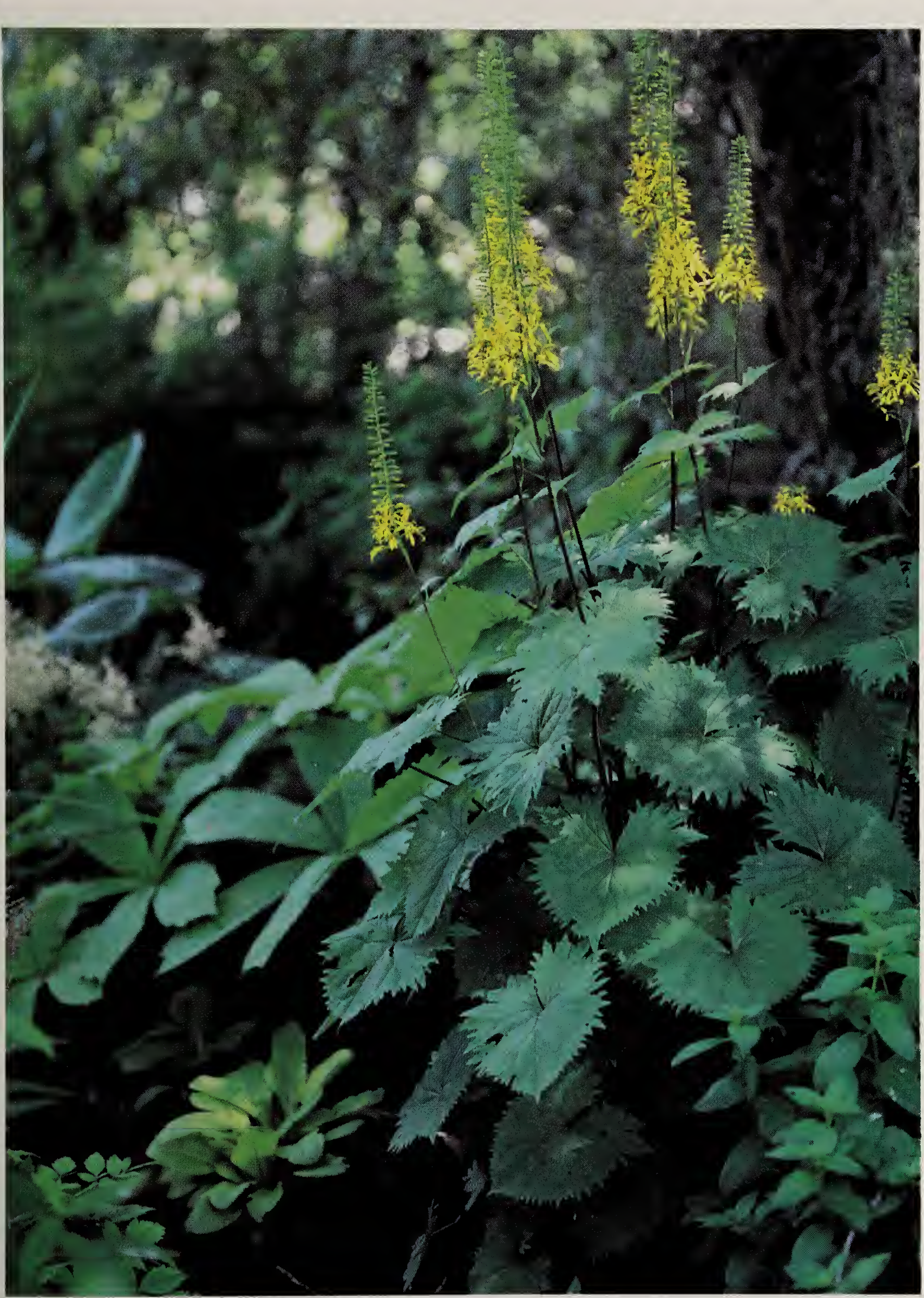
A raised bed with shade-loving plants.

photo: Ken Slump

Shade gardening is often entwined with woodland gardening but this is not necessarily true. By name, the latter uses trees as the predominant feature but a shade garden can also be in a completely open space on the north side of a structure. Quite consistently, however, mountain homesites have trees on the property. As nearly every community has spread dramatically outward, many homes are being set amongst the forest.

The variety of pine species, with their differing growth habits and patterns, provides varying amounts of shade. In the case of the lodgepole pine (*Pinus contorta* ssp. *latifolia*), growth is so dense that all plant life on the forest floor is obliterated. With ponderosa pine (*Pinus ponderosa* ssp. *scopulorum*) communities, the trees can be relatively widely spaced, creating a partially shaded habitat. It is possible to create a shade garden under the ponderosa pine's canopy, but not under the lodgepole pine. We also need to remember that with any tree, the majority of the plant is underground. So, when creating your garden a major question is, how densely the roots are penetrating your proposed site? You can, of course, use raised beds to avoid this problem. Raised beds may be free standing or built against a structure and are interesting when constructed in different sizes and widths.

by Andrew Pierce



Ligularia '*The Rocket*' *thrives in shady locations.* *photo: Rob Proctor*

Hosta – always reliable in the shade. *photo: Rob Proctor*

Another factor that frustrates shade gardeners is the fact that snow lays much longer on the northern exposures at increased elevation due to generally colder conditions — perhaps 5 degrees for every 1000 feet. During a recent winter season, the front range experienced heavy snowfalls in October, followed by minimal precipitation until the spring, yet snow banks persisted in the foothills into April and May. In this type of circumstance, final thawing may not occur until June, which leaves only three months of growing season — and much of that is not frost free.

Your Growing Medium

The natural soil will in most cases consist of broken rock and fine gravel, with wonderful drainage that is much more suitable to a rock garden than for those prized shade plants you cherish. Occasionally, the local soil may be sandy alluvial river bottom — consider yourself lucky — or even less frequently, almost marshy, where drainage has been severely interrupted. In almost all cases, you will probably find it necessary to amend your soil heavily or even produce your own "synthetic mix." The question as to what to amend your soil with will depend on plant choice, but for general culture, always address these "5 main requirements": 1) drainage, 2) water holding capacity, 3) pH, 4) organic material and 5) nutrients.

Asking questions first can save time and money in the future. There is no substitute for a good friable, or "crumbly," soil that has 25-35% organic material content. The remainder should be of a loamy character rather than clay. If your garden area is relatively small, it may pay to purchase "planters mix" and add another 10-15% organic material. A working depth of 12 to 15 inches over 2 inches of base drainage material is ideal. The soil's pH level should be in the range of 6.5 to 7.5. If you are unsure or concerned about your soil's pH, testing can be performed to determine the acidity or alkalinity levels. Contact your local Cooperative Extension office for more information. Most soils, however, are typically acceptable for planting.

Design Location Influences

Beyond the importance of good soil, location and the amount of sun penetration are key. When selecting your site, start small but look a few years beyond your first concept since your success and enthusiasm may eventually need more space. There is perhaps no ideal site and very often we have to create our own environment with nature's influence. Remember the angle of the sun when planning any garden. Also, the higher the elevation, the lower the temperature — yes, day and night! This means that you can place a true shade-loving plant in a bit more sun and get away with it.

A really densely shaded area will be very difficult to garden and those few shade plants that do survive will offer foliage only. A significant amount of sunshine, such as three to four hours a day, will enable a larger plant selection to be grown. This amount of light may be three to four hours directly from the east and west, or dappled shade from trees overhead. With six to seven hours of sunlight a day, even more plants will succeed.

Even at higher elevations, occasional additional watering will be required during the summer, but it may not be cost effective or necessary to install a sprinkler system, especially if the initial soil was prepared with adequate organic material. When it is necessary, water your shade garden thoroughly and deeply rather than sprinkling daily.

When siting your garden, be sure to avoid "frost pockets" that hold cold air in hollows for extended periods. Cold air rolls downhill so make sure that structures or other plantings don't trap cold air. For example, if there are such obstructions, early frosts can damage the foliage of tender plants such as hosta as much as two weeks earlier than in a well "air-drained" location.

With the limited growing season available at higher altitudes, planting shouldn't typically occur until early June. Therefore it is advisable to use larger, more established plants in containers such as 4" or larger. Make sure your plants go into a damp soil and water thoroughly after planting. Use fertilizers with a low nitrogen value such as 5-10-5. Short, stocky, well-flowering plants should be selected. Planting areas may be dressed with a thin layer of good-looking mulch which will help with weed control and water retention. Crowns of plants should not be covered or else winter rot may occur. Fall clean-up can include cutting down plants to a few inches, but often low clumps such as dwarf ornamental grass, columbine, and hosta should be left until the spring.

Recommended Shade Plants:

Aconitum spp. — monkshoods
Aquilegia caerulea —
Colorado blue columbine
Bergenia cordifolia — bergenia
Dicentra spectabilis — bleeding heart
Doronicum orientale — leopard's bane
Galanthus nivalis —
common snowdrop
Hepatica acutiloba — hepatica
Hosta cvs. — plantain lilies/hostas
Matteuccia struthiopteris —
ostrich fern
Mertensia virginica —
Virginia bluebells
Phalaris arundinacea var. *picta* —
ribbon grass
Polemonium caeruleum —
Jacob's ladder
Pulsatilla vulgaris — pasque flower
Stachys grandiflora — betony
Thalictrum spp. — meadow rues
Trillium grandiflorum —
white wake robin
Woodsia spp. — woodsia ferns

AUTHOR BIOGRAPHY
Currently director of horticulture and education at Hudson Gardens in Littleton, CO, Andrew Pierce has more than 40 years of horticulture experience, including 18 years at Denver Botanic Gardens. Pierce, who resides in Evergreen, CO, is also a board member of the Vail Alpine Garden Foundation and the Colorado Garden and Home Show.

An assortment of shade-loving plants. *photo: Ken Slump*

GARDENS ON THE ROCKS

Have you ever driven by an idyllic hideaway, tucked in the folds of a mountain, when you notice a desperate fellow riding a noisy lawn mower, fiercely attempting to transform what was once a lovely meadow of wildflowers into a crewcut urban lawn? What is it about human nature that makes a fairly normal creature (like me) attempt to build little mountains in town, plant them up with fussy plants from mountaintops, and conversely put others in a wild setting, where they struggle to strap poor Mother Nature in a straightjacket of formal gardening?

The first principle I propose for mountain gardeners is to preserve as much of your property in a pristine state as you possibly can. If your land is relatively undisturbed, I would suggest you do absolutely nothing to it. Walk it by all means, take lots of notes, compile a species list. Remove exotic and deleterious weeds, preferably by hand. When you are blessed with a natural undisturbed setting you have that original garden, an Eden, that holy grail of urban gardeners: a no maintenance garden. Enjoy and keep your mitts and mowers off it.

But you want to garden, you need to get your hands dirty, you are desperate to have a bit more color or drama than your native setting offers much of the year. It is, after all, a free country and what people do in the privacy of their own garden beds is their own business.

For most homeowners, I would imagine that a series of borders and garden beds in the vicinity of the house would be more than adequate for playing out their garden fantasies. In some level settings, a cottage type garden might be an excellent way to go. In many quaint mountain towns, trim beds of Icelandic poppies or pansies often turn into sound perennials, where they would be strictly annual at lower elevations. By and large, most mountain homeowners are advised to work mostly with informal plantings and borders, or best of all rock gardens, since these complement our asymmetrical mountain setting better than rigid, formal design.

Why a rock garden? Rock is, after all, the very heart of mountains. Well placed rock in a garden provides a dramatic, architectural link with the surrounding massifs, and nothing sets off a plant as simply or directly as solid rock. Most importantly, a large proportion of the montane flora of the world are plants that grow best in and around rocks. There are many plants which grow only on the surface, or in tiny crevices of rocks.

In botanical parlance these are called chasmophytes, or saxatile plants. Chasmophytes literally means"plants that grow in chasms, usually on vertical cliffs."Saxatile is derived from *saxum*—the Latin

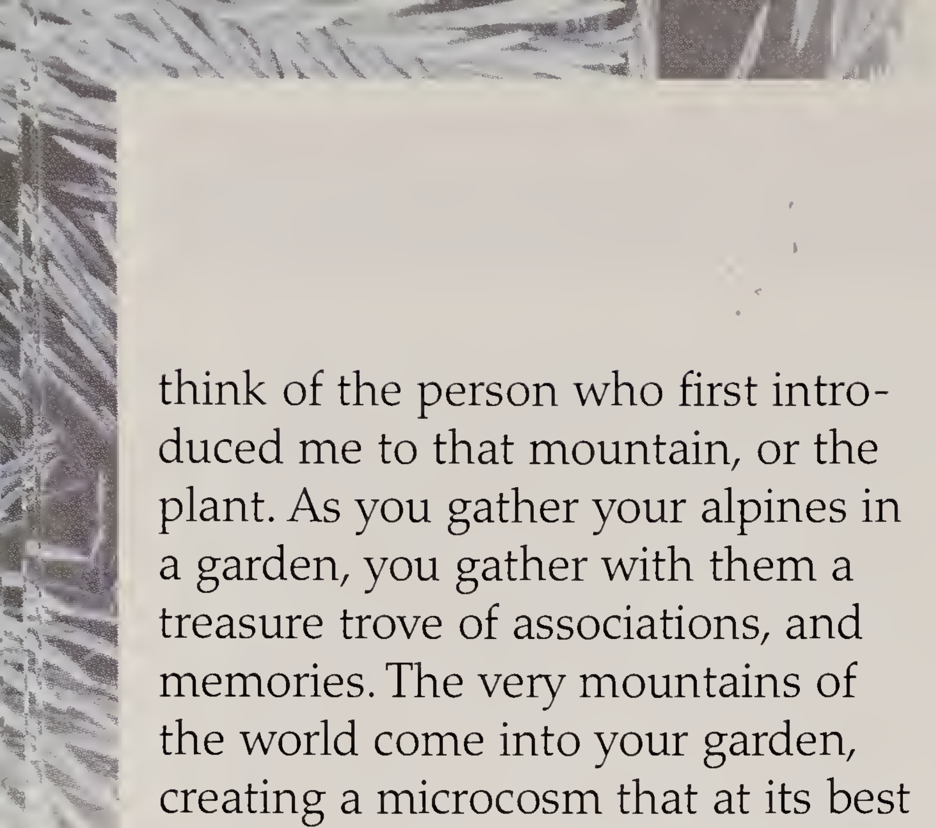
By Panayoti Kelaidis

word for rock. A saxatile plant is only found in or on rocks in nature. In a garden, these will only flourish among rocks. They include a large proportion of our showiest native plants, and those from similar climates. In other words, only a rock garden can accommodate the showiest mountain plants: lewisias, saxifrages, many primulas, androsaces and such choice morsels as the alpine gesneriads of Europe to name a few.

Unlike borders, which are designed almost exclusively for their color combinations and the artful way they blend and fit into a context, rock gardens are more eclectic. Since plants are often separated from one another by rock, they stand out more than plants in borders or uniform plantings.

Rock gardeners have a fascination with the plant itself. More than any kind of garden, rock gardens are the cult of wild flowers, of botanical curiosity. For me, the plants I grow in my rock garden are emblematic as well as aesthetic objects: when they bloom I may marvel at the beauty of their flowers, but I often think of where they come from, and a whole series of associations tumble forth. I often

Delosperma '*Gold Nugget*' *photo: Panayoti Kelaidis*



think of the person who first introduced me to that mountain, or the plant. As you gather your alpines in a garden, you gather with them a treasure trove of associations, and memories. The very mountains of the world come into your garden, creating a microcosm that at its best is the very expression of your life, your soul.

Following are some of my tried and true favorites:

Androsace sarmentosa
(Himalayan rock jasmine)

The Himalayas are home to the greatest variety and range of rock jasmines. Most of these sun-loving cousins of the shady primrose clan produce a ball-shaped rosette, frequently sporting a coat of hairs. The majority have short, strawberry like runners.

Androsace sarmentosa is probably the most robust rock jasmine. It produces bright mahogany runners that romp and spread through the garden with gusto. The flowers can vary from near white to chalky pink, and some approach a purple/magenta hue that is quite eye-catching (var. *chumbyi,* or var. *watkinsii*). This plant can quickly transform well drained slopes or crevices in a rock garden into cascades of rosettes in stunning mid-spring bloom. This is the sort of dazzling plant that justifies the existence of even the smallest rock garden.

Aquilegia saximontana
(Rocky Mountain columbine)

Everyone knows the Colorado state flower, *Aquilegia caerulea,* which can be still found in abundance throughout the state from foothills to tundra. I first became aware of its tiny, alpine cousin when I was a child and purchased a Denver Museum of Natural History pictorial on native plants. A charming picture showed a few, distinctive nodding flowers—like a fairy-tale version of the state flower—nodding over a dark granite boulder. The shape of these was so distinctive, and they were obviously minute. Despite their blue and white coloration, the Colorado alpine columbine is not closely related to our state flower: its nearest relatives grow far to the north, as well as across Eurasia. Of course, I had to see this plant and eventually to grow it.

Fortunately, very little will ever disturb the rugged cliffs and rock slides where this local plant grows in nature. You can purchase thrifty plants of this from garden centers every spring.

Delosperma 'Gold Nugget'
(Gold Nugget™ ice plant)

A prominent gardening author wrote recently that all the best plants have been introduced to gardens, and we presumably are left only with the task, the craft, of putting them together. It's obvious that the author has spent little or no time in the American West, or in South Africa for that matter. In the last two decades, over 100 species of ice plants previously unknown to horticulture have survived at least one Colorado winter.

One of the showiest may also be one of the rarest. On a trip I made to the summit of a heavily trafficked and overgrazed pass in the Drakensberg Mountains (on the border of Lesotho and Kwa-Zulu Natal province in South Africa), we found only a very few ice plants. This one grows in thin mats of grass that can be soaking wet much of the summer season. It somewhat resembles the familiar yellow ice plant, although in this species the foliage is constricted into tight mounds and the flowers have a bright white center to their yellow petals. We have found nothing to match this plant in botanical books, nor in America's premier herbaria, nor at the Compton Herbarium at National Botanic Gardens at Kirstenbosch, South Africa. It represents one of a dozen or so distinctive plants at Denver Botanic Gardens awaiting a monographer to name it. This plant is very difficult to locate but worth the effort.

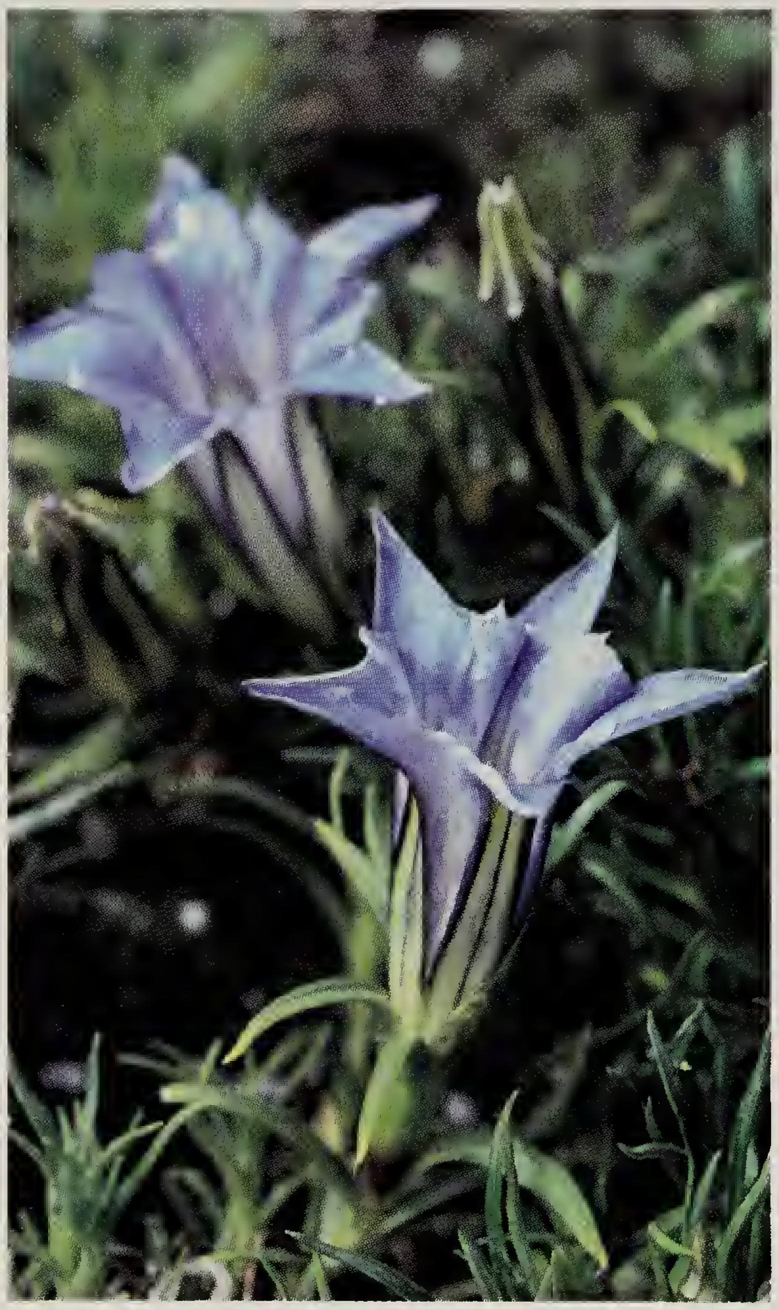
Eriogonum umbellatum
(Sulfur flower)

Sulfur flower is one of the more widely distributed, abundant plants in the West. There are forms restricted to the highest tundra that are barely an inch tall in bloom, and shrubby forms that approach two feet in height that grow in sagebrush desert. Most of the dozens of variations of this species have flowers of a chartreuse tint. As the flowers age, the color deepens to gorgeous sunset orange and reddish shades. The color can also vary to pure white, through every shade of pink and fawn to the deep red of 'Alturas Red'.

Some plants will have powdery gray tomentum on the leaves, like floral polar bears, while others will be glossy green the year around. Most make evergreen mats or mounds that turn a wine red in the winter. This is a plant for all seasons and for every sunny garden.

Gentiana farreri
(Farrer's gentian)

While the most famous European gentians bloom in early spring, the largest groups, which are Asiatic, bloom from midsummer



Gentiana farreri *photo: Panayoti Kelaidis*

until season's-end. If you live below 6,000 feet elevation, you will find many Himalayan plants to be challenging, but the higher in the mountains you garden, the more robustly, quickly and gloriously you can expect the grassy Himalayan gentians to perform.

Possibly the most stunning of these is this robin's egg blue miniature with long, striped blossoms pointing toward the sky. In a well grown specimen, this dome can be the floral equivalent of a neon sign. Plant it in rich, well drained compost, top annually with well rotted manure, and lift and divide clumps every four to ten years. You will be the envy of your neighborhood.

Lewisia cotyledon
(Siskiyou bitterroot)

Few garden plants can approach a mound of Siskiyou bitterroot in full bloom; the strap-shaped evergreen leaves make a wonderful, evergreen rosette. Properly grown, these rosettes practically disappear beneath a mound of 1-2″ waxy-textured, multipetalled flowers that recall succulent roses in their brilliance and textures. They can be pure white, soft to neon pink, near scarlet, maroon, purple, magenta or the entire sunset range of yellows and oranges, as bright as a heap of hard candy under lights.

Lewisias are notoriously short lived in hot and humid climates, but grow more easily and permanently at higher elevations. They love a good, rich compost amended with gravel, and a gravel mulch at the neck. Or, best of all, Lewisias will thrive in a rock niche, rock wall or rock garden where they can splay out gracefully with their outrageous display of color.

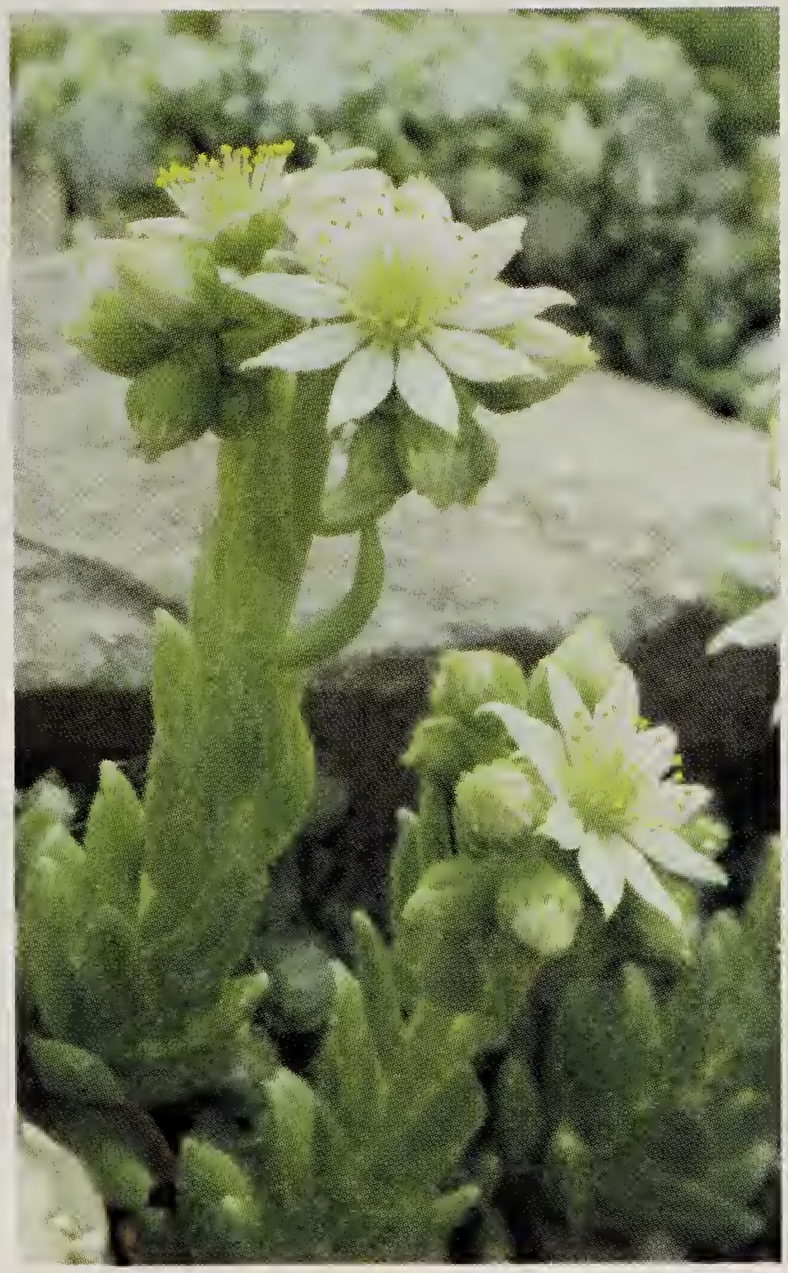
Sempervivum arachnoideum
(Cobweb houseleek)

Imagine a particularly dense, miniature sempervivum with each leaftip attached to the other by a dense mesh of white, cobwebby filaments such that the entire rosette becomes a veritable ball of whiteness. Now imagine an 8″ flower stem producing the most heavenly Victorian pink multipetalled flowers with a dark center of emphatic stamens and you have one of the most astonishing, easily grown and wonderful rock garden plants available. Given lots of bright sun, a well drained scree soil, or even loam, this plant will spread with tremendous gusto and make quite a spectacle with its brilliant flowers. There is a pure white form, selectively bred by a famous Dutch hybridizer named Mr. Zonnevold, that is every bit as stunning.

Primula auricula
(Bear's ear primrose)

Those who know the Alps will tell you that you may sing "Edelweiss" til the cows come home, but the true kings and queens of the alps are gentians and primroses respectively. Unlike the hundreds of species of Himalayan primroses, which are often immense in stature, and bog or deep woodland loving, the European primroses are usually plants of crevices or turfy meadows.

They produce trim rosettes of nearly succulent foliage that is often covered with a powdery meal of whiteness that resembles baking powder or sifted flour. The flower stems and flower calyxes are similarly powdery. The flowers themselves are velvety, yellow bell-shaped funnels that have the sweetest fragrance.



Sempervivum arachnoideum *photo: Panayoti Kelaidis*

AUTHOR BIOGRAPHY
Panayoti Kelaidis, plant evaluation coordinator and curator of Denver Botanic Gardens Rock Alpine Garden is also known as "Mr. Ice Plant," for his introductions of numerous plants from South Africa and similar climates around the world.

ATTRACTING "HUMMERS" TO YOUR HABITAT

Hummingbirds are abundant in the Colorado mountains in the summer months, primarily because of plentiful food sources provided by native flowers.

The predominant seasonal resident and breeder is the broad-tailed hummingbird. The male is distinguished by a bright red throat and by his distinctive audible buzzing produced by wing feathers. Another common hummingbird that migrates through our state is the rufous hummingbird. This bird does not nest in the state, but is commonly seen in montane meadows from about July 7th through September 10th. Other less predominant variants are the black-chinned and calliope hummingbirds, who depend on flower nectar as their main food source.

Hummingbirds are attracted to the color red, hence red flowers draw them to a specific area for feeding and exploration. Successful food sources need not be red in color, but red should be present in some part of the garden to attract hummingbirds.

To insure a June to September sequential flowering period, select a variety of both early and late blooming plant species. An early blooming plant for Colorado mountain hummingbird gardens is bleeding heart (*Dicentra spectabilis*). This old-fashioned, non-native perennial likes shade to semi-shade. Arching stems about 1 1/2 feet tall give way to bright pink hearts. Bleeding heart likes consistently moist soil.

Coral bells (*Heuchera sanguinea*) blossoms a bit later than bleeding heart and it is very hardy in higher elevations. Bell-shaped coral to red flowers are found on green spikes which stand above a mound of dark green leaves. If spent flowers are removed, the plant may continue to flower throughout the season.

Wax currant (*Ribes cereum*) and golden currant (*Ribes aureum*) are Colorado native shrubs which flower fairly early and delight hummingbirds. Both plants have tubular flowers, which perfectly fit a hummingbird's slender bill. Tubular flowers work well to keep nectar beyond the reach of a honeybee's short tongue. Both plants can take dry soil and full sun, although golden currant can be grown in semi-shade as well.

Another shrub for the Rocky Mountain region which broad-tailed hummingbirds favor is the old fashioned common purple lilac (*Syringa vulgaris*). Butterflies find the nectar of the blossoms palatable too. The native mountain snowberry (*Symphoricarpos oreophilus*), a two to five foot high shrub has pink tubular flowers, 1/3 to 1/2 inch long. The plant has an overall graceful arching habit. The flowers are followed by white

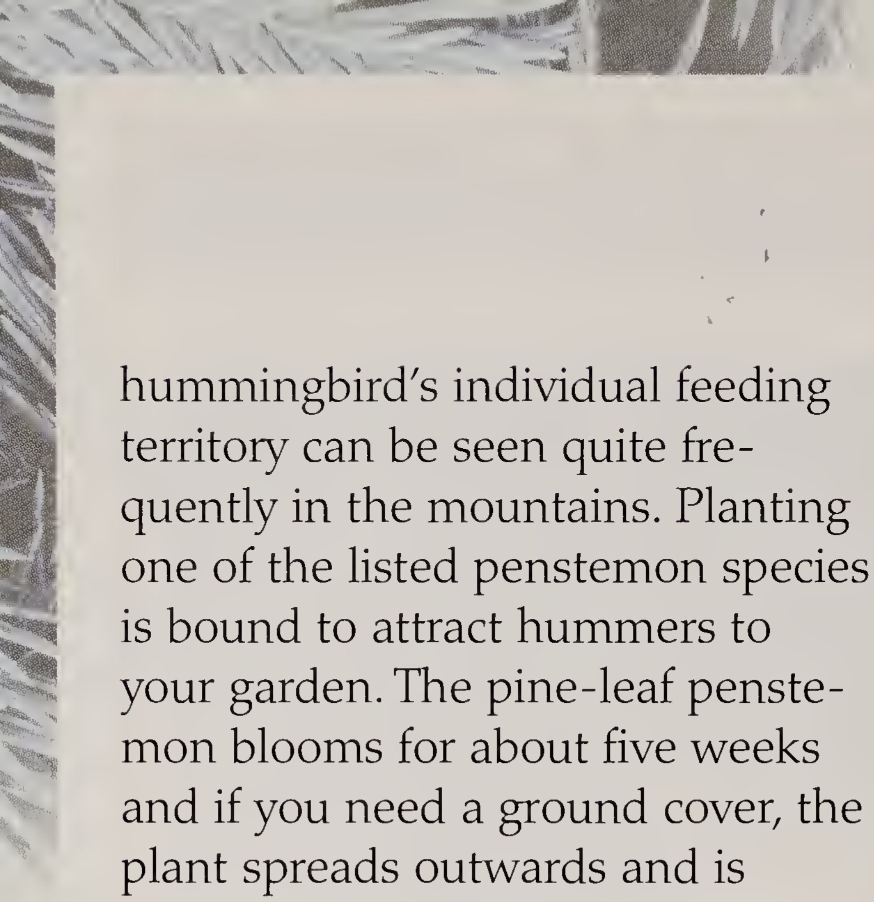
By Tina Jones

Broadtailed hummer at Ipomopsis aggregata. *photo: Wendy Shattil/Rob Rozinski*

berries which are enjoyed by songbirds. No hummingbird garden should be without Arnold's red honeysuckle (*Lonicera tatarica* 'Arnold's Red'). This shrub has arching branches with oval leaves and reaches a height of about seven feet. Reddish-pink tubular flowers provide nectar food for hummers. The shrub is hardy at higher elevations and likes sun to part shade.

By early summer, many showy penstemons are blooming in the mountains. Penstemons and hummingbirds have evolved together. The hummer feeds on the penstemon nectar, and while feeding, it hopefully pollinates the flower. Occasionally, one may see the light yellow or whitish dusting of pollen on the forehead of a hummingbird. Firecracker penstemon (*Penstemon eatonii*), scarlet bugler (*Penstemon barbatus*) and pine-leaf penstemon (*Penstemon pinifolius*) have scarlet red flowers. The first two are Colorado natives and the latter is native to New Mexico.

Aerial disputes are commonly fought over and around penstemons. Nothing is more important to a hummer than its nectar supply and certain penstemons have very high nectar content. Defending a



hummingbird's individual feeding territory can be seen quite frequently in the mountains. Planting one of the listed penstemon species is bound to attract hummers to your garden. The pine-leaf penstemon blooms for about five weeks and if you need a ground cover, the plant spreads outwards and is densely covered with needle-like, linear leaves. This penstemon grows to a height of about 12" whereas the other two grow to about two feet.

Although hummers usually are attracted to the color spectrum of red, they will feed from flowers of other colors. By experimentally feeding on different flowers, they learn which ones have the highest nectar content. Two blue-flowered penstemons which are native and favored by these birds are clustered penstemon (*Penstemon procerus*) and blue mist penstemon (*Penstemon virens*). Both plants are about 10" tall.

Other flowers in the blue to purple range which attract hummingbirds are Colorado blue columbine (*Aquilegia caerulea*) and delphinium (*Delphinium* hybrids). Our common native lupine (*Lupinus argenteus*) is a major food source for hummers in the wild. The sky blue-colored flowers are "hummer magnets," whereas the larger-sized cultivated lupines do not seem to interest hummingbirds as much.

Another nectar source commonly sought by hummers is the Indian paintbrush (*Castilleja integra*). Almost everyone has seen hummingbirds feeding on this native in the mountain ecosystem. Hummingbirds also eat tiny insects which can be lured to your garden by sunflower (*Helianthus annuus*).

Bee balm (*Monarda didyma* cvs.) is another perennial to include in your garden. This plant can take full sun to semi-shade and is usually quite fragrant and very easy to grow. You can buy pink, fuchsia or the hot red cultivar 'Cambridge Scarlet'.

Colorado mountain hummingbird gardening would not be complete without mentioning the all time favorite nectar plant, fairy trumpet or scarlet gilia (*Ipomopsis aggregata*). This is one of the very top hummingbird plants to have in your garden. It is a native biennial. The flower stalk grows to a height of about 22", and comes up the second year of growth. In the wild, the trumpet-like flowers come in colors of coral, pink, orange and scarlet red. The flower stem arches slightly while all the individual trumpets droop down. The flowers are about 1 3/4" long. The tip of the flower flares out into five pointed lobes. This plant is sought out and fought over by hummers. It likes full sun and excellent drainage.

One can also supplement their yard with annuals to attract hummingbirds. Hanging baskets or containers of fuchsia, salvia, verbena and nasturtium are just a few suggestions. Remember that some species of annuals must have a certain amount of protection from climatic conditions. Consideration of the different microclimates in your yard and garden will provide you with more satisfactory results.

In conclusion, it is important to think of the hummingbirds' safety if one is going to try to attract them. Hummers do not live on nectar alone. They ingest tiny insects, spider mites and pollen grains which in turn provide them with protein, minerals, fats and vitamins.

Pesticide spraying can definitely affect hummers in a very negative way. Another safety issue is cats. Cats do eat hummingbirds at times. If there is any question, keep cats inside the house. The positive side to this is that cats live longer when they are not outside. Song-birds in general are dropping in numbers in North America. There is some question as to whether hummingbird populations are declining also. One can help hummers by creating a friendly habitat for them with food (nectar sources), shade and water.

AUTHOR BIOGRAPHY

Tina Jones of Littleton, CO, is a wildlife consultant in landscaping for songbirds, hummingbirds and other wildlife. Her yard has been featured in several articles as an example of establishing a backyard habitat for birds. She reviewed the Western Mountains chapter and provided a regional hummer plant list for the book, *Hummingbird Gardens* by Nancy L. Newfield and Barbara Nielson.

Lupine and columbine are attractive to hummingbirds.

photo: Rob Proctor

Enhance your Landscape with Container Gardens

Do you live in a condo or a townhouse in the mountains with no yard? What's a gardener to do? Container gardens may be your answer. They can provide an amazing variety of gardening opportunities in a small space. Balconies, patios, front entrances and outdoor decks become garden "beds" to be arranged with all the creativity you would bring to a large garden.

You need to plan a container landscape with all the care you would use in planning any garden. Provide contrasts in both containers and plants. Think of the variety that you can bring to a small space: flowering plants can be moved to foreground or background with the season. A trellis on an outside wall can become a garden for vines or climbing vegetables. A tub or grouping of containers with a large tree and shrubs may fill a gap or screen neighbors from view. Pots and tubs, hanging baskets, strawberry pots, garden towers, small sculptures — the mixing and matching of containers and plants is almost endless.

If your yard has a lot of shade, put your plants on wheels and move them around during the day to follow the sun. You may be able to grow some favorite vegetables or herbs in pots that you haven't been able to grow before. Containers also allow you to bring plants indoors on cold nights in early and late season.

Tips for Container Gardening

- Whether you are planting a window box or a pot, crowd it with plants. Then water and fertilize frequently. Do not allow containers to dry out! Overplanting allows you to get more plants into a small space, providing greater variety in a small herb garden or a colorful annual display.

- Choose plants that provide contrasts in color, texture, height and foliage. Use foliage plants as well as flowers, perhaps choosing trees and shrubs with colorful fall foliage or evergreens that provide accents in the winter landscape.

- Look for variety in containers — tubs, boxes, barrels, troughs and pots with different colors, materials and finishes. Then arrange your containers in attractive groups. Triangular groupings are often the most pleasing.

- Get more than one season in a container by using spring (or summer) bulbs planted beneath a ground cover in a pot whose main tenant is a tree. Snow crocus, species tulips and daffodils,

By Helen Fritch

among others, are a welcome greeting in the spring. Later, color may come from a planting of annuals following an early spring display.

- Be aware that trees and shrubs will not thrive in containers indefinitely. Decreased vigor may indicate a need for relocation to a larger space. An alternative is to root prune when dormant and replant in the same container.
- Perennials have a shorter blooming season and are better suited to pots which can be moved to the background when their bloom is ended. Choose perennials with attractive foliage that you will still enjoy when they are not in bloom. Foliage plants like hosta, or trailing vines such as vinca, can be planted in combination to provide other interest in the container.

A mountain container garden.

photo: Rob Proctor

- Don't mix sun and shade loving plants in the same pot. Analyze the sunlight in your planting areas to know how much sun your plants will receive and when. Early morning sun is not as hot as late afternoon sun. Shade lovers may tolerate some morning sun but must be protected from the sun in the afternoon. Vegetables need as much sun as they can get.

- "Veggies" for the mountains? What you can grow will depend on altitude and exposure. Look for the earliest varieties in catalogs as a guide to selection. "Cool season" types succeed best. They can be mixed in containers with flowers or trees, such as a lettuce border or a trellis with edible-pod pea and morning glory.

Trough Gardens: Alpine Gardens in Miniature

Trough gardens show off alpine plants in small landscapes that suit the size of these tiny plants. They are ideal gardens for mountain gardeners who have only a balcony or doorstep. Troughs, like other containers, allow you to vary the soil mix to meet the needs of the plants you choose.

Traditional troughs are made of a "hypertufa" mix — Portland cement, peat moss and perlite. They may be round, square or rectangular. Look for troughs at plant nurseries that specialize in alpine plants or do some research and make your own.

Colorful plants grow in a trough. *photo: Helen Fritch*

Choose alpines that bloom at different times during the summer for a succession of bloom, or plant several varieties of one species, like dianthus, for a spectacular display all at once. Use rocks or weathered wood to create structural elements in your landscape. Several rocks from the same rock formation give continuity to the landscape, just as they do in nature.

Water Gardens: Small Pools by the Barrel

A water garden provides an interesting focal point on a deck or patio. Use a half whiskey barrel (with a plastic liner, or cured so the staves expand to make the barrel watertight), a water trough or other large waterproof container. Look in garden supply centers for barrels, tubs or a water garden "kit" with a submersible pump and small fountain or bubbler.

There are basically two groups of water plants — floaters and those planted in soil. Most do best in full sun. If you choose plants like water lilies that require soil, place the soil in a separate container in the bottom of the barrel and cover it with small rocks or gravel to keep the water clean.

If you choose to add goldfish, the plants will feed them, and a small fountain or aerator will oxygenate the water. In winter, bring the goldfish inside. Bring the plants in, too, or replant in the spring as you would an annual garden. A word of warning — deer, elk and raccoons also like water plants. If they are a problem in your area, you will need to place your water garden out of their reach.

Easy Plants to Grow in Containers

Trees

Malus spp. and cvs. — crabapples
Picea 'Fat Albert' — Fat Albert spruce
Picea 'Montgomery' — Montgomery spruce
Populus tremuloides — quaking aspen

Shrubs

Cornus sericea — red-twig dogwood
Cornus sericea 'Flaviramea' — yellow-twig dogwood
Cytisus scoparius 'Moonlight' — Moonlight broom
Mahonia repens — creeping Oregon grape
Potentilla fruticosa — shrubby cinquefoil
Prunus cerasifera 'Newport' — Newport purple leaf plum
Rosa foetida 'Bicolor' — Austrian copper rose

Perennials and Bulbs

Allium spp. — ornamental onions
Colchicum autumnale — autumn crocus
Crocus spp. and cvs. — crocuses
Echinacea purpurea — purple coneflower
Hemerocallis cvs. — daylilies
Lilium cvs. — Asiatic hybrid lily
Monarda didyma cvs. — bee balms
Narcissus cvs. — daffodils
Tulipa spp. and cvs. — tulips

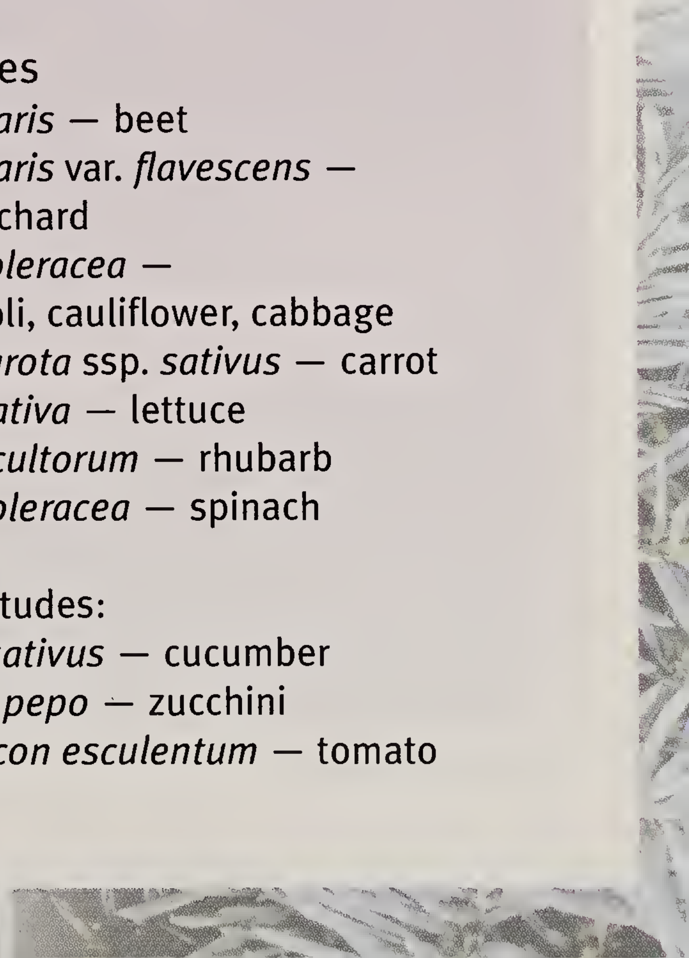
Annuals

Begonia cvs. — begonias
Brassica oleracea — flowering kale
Impatiens cvs. — impatiens
Ipomoea tricolor — morning glory
Lobelia erinus — lobelia
Papaver nudicaule — Icelandic poppy
Pelargonium cvs. — geraniums
Petunia cvs. — petunias

Vegetables

Beta vulgaris — beet
Beta vulgaris var. *flavescens* — swiss chard
Brassica oleracea — broccoli, cauliflower, cabbage
Daucus carota ssp. *sativus* — carrot
Lactuca sativa — lettuce
Rheum x *cultorum* — rhubarb
Spinacia oleracea — spinach

Lower Altitudes:
Cucumis sativus — cucumber
Cucurbita pepo — zucchini
Lycopersicon esculentum — tomato



Trough Garden Alpines

Androsace spp. — rock jasmines
Aquilegia elegantula —
western red columbine
Aquilegia jonesii — Jones columbine
Aquilegia saximontana —
Rocky Mountain columbine
Armeria spp. — thrifts
Campanula cochleariifolia —
dwarf bellflower
Campanula tridentata — bellflower
Dianthus spp. — pinks
Gentiana acaulis — stemless gentian
Gentiana sino-ornata — gentian
Gypsophila repens 'Rosea' —
dwarf pink baby's breath

Water Gardens

Azolla pinnata — water fern
Cyperus alternifolius 'Gracilis' —
dwarf umbrella plant
Eichhornia crassipes — water hyacinth
Equisetum spp. — dwarf horsetails
Lemna minor — common duckweed
Myriophyllum aquaticum — parrot's feather
Nymphaea x *marliacea* 'Chromatella' —
Chromatella yellow hardy water lily

Of course, you can grow many more plants than these in containers. Look through seed catalogs and visit local nurseries. Ask questions about what will grow best at your altitude. Mountain gardening covers quite a range! Look at your deck, balcony or patio with "new eyes" of imagination. You may be surprised to find an exciting gardening adventure in your future.

A garden in containers near Edwards, CO.

AUTHOR BIOGRAPHY
Helen Fritch of Vail, CO, is president and a founding member of the board of Vail Alpine Garden Foundation, developer of Betty Ford Alpine Gardens in Vail.

photo: Ken Slump

After experiencing 10 years of gardening next to the White River National Forest I thought I had all the angles covered in my attempt to outsmart the wildlife. But that was before I made a peanut butter pie!

Growing flowers and vegetables in the mountains presents many problems not usually faced by city gardeners. At 9,000 feet, all I thought I had to contend with was a short growing season. I quickly learned that creatures from the forest wreaked far more damage than a 4th of July snowstorm ever did.

My first season I was reminded of the song made famous by The Kingston Trio, "Where have all the flowers gone?" Guilty sentences were pronounced on deer, elk, bear, rabbit, chipmunk, badger, raccoon, porcupine, squirrel, mole, vole, marmot and even a moose. There are probably others that have not yet been seen committing the crime of garden desecration.

I used everything I could find in an attempt to save my garden. Moth balls or strong soap hung in the feet of panty hose, cayenne pepper, hot pepper sauce, ammonia mixed with Fels Naptha soap, human hair, talcum powder and blood meal all found their way into my garden. One article suggested urine as a repellent. That repelled me. All these so called remedies not only failed as deterrents, but they were unsightly. The blood meal provided too much nitrogen in my soil. Care had to be taken to keep the strong soap from dripping onto the flowers. I next tried moving around plastic snakes, owls and cats. Who was I trying to fool?

Where's dessert?

By Barbara DeVoe

Finally I experimented with Ropel, a commercial product which produced some success as long as it did not rain. I found the best reference book concerning pests, mammal and otherwise, is *Bugs, Slugs and Other Thugs* by Rhonda Hart.

At one time I raged total war with one particular rabbit. My method was to throw missiles near it with the intent of scaring it away. This only worked for the moment. I finally won the battle when I accidentally scored a direct hit.

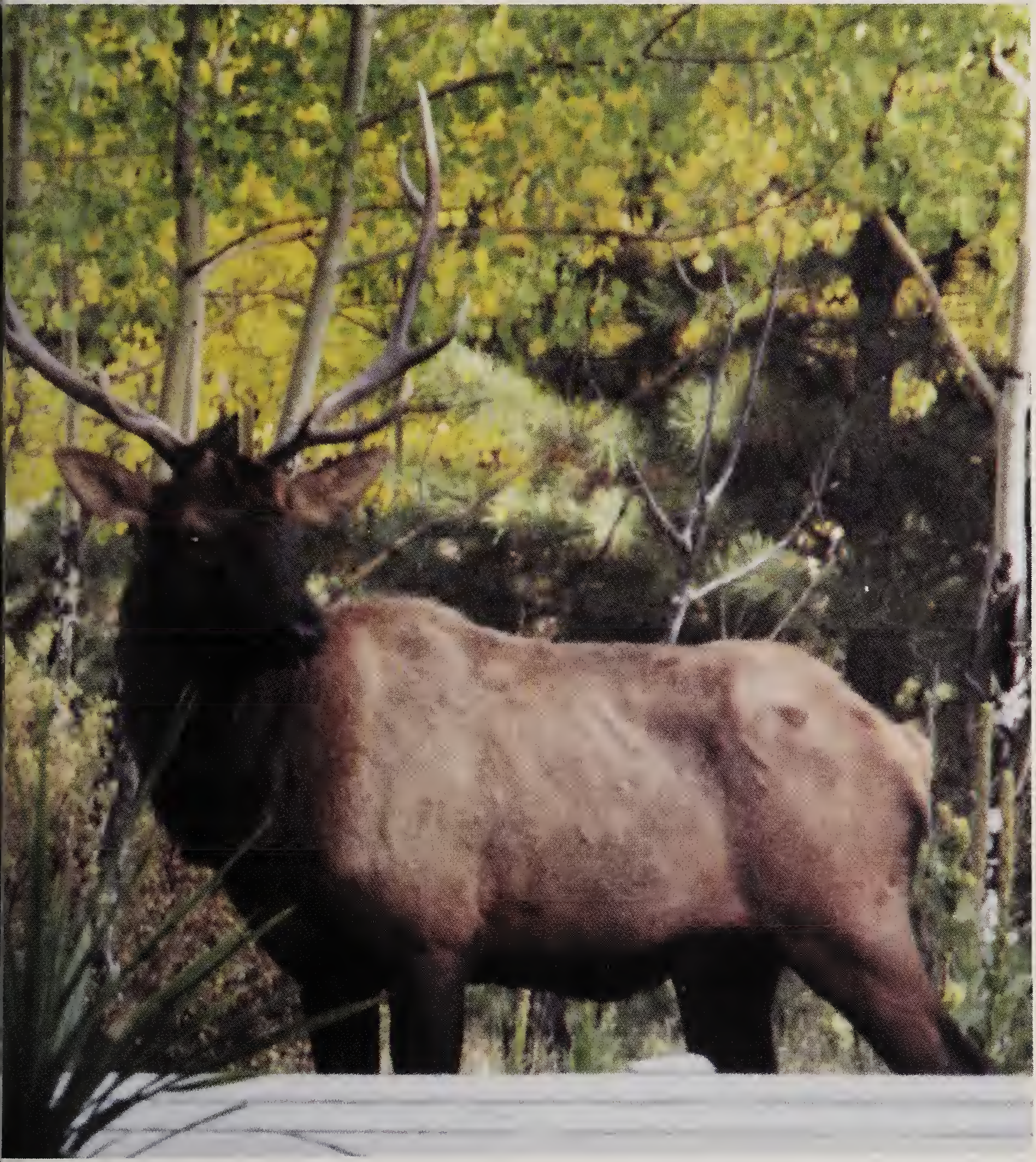


photo: Nat Robinson

Moth balls in panty hose–to repel whom? *photo: Julie Behrens*

Stunned, this particular rabbit got the message. I do not mean to promote this type of combat — though on occasion it does work.

I was losing the battle. So I decided to adapt those old adages: "If you can't beat'em, join'em" and "The best defense is a good offense." After all I was living in their habitat. They were here long before I chose this site to build my garden.

Here is my strategy now. No doubt the biggest wildlife problems are browsing deer and elk. While nothing can truly deter them, some measures have been fairly successful. In the outer perimeters of my garden I planted flowers of which they are especially fond: delphinium, phlox, hosta and pansy. They tend to nibble here and then move back into the forest. I call it my sacrificial garden.

Animals tend to avoid narcissus bulbs, so I rely on them for spring color instead of the tastier tulip. However, a trip to Holland did weaken my resolve on that point. Despite claims, I find that few plants are deer resistant and most sources disagree on which they like or dislike. If at a future time my sacrificial garden fails, I plan to lay wire fencing on the ground. Deer "supposedly" dislike walking or jumping over wire.

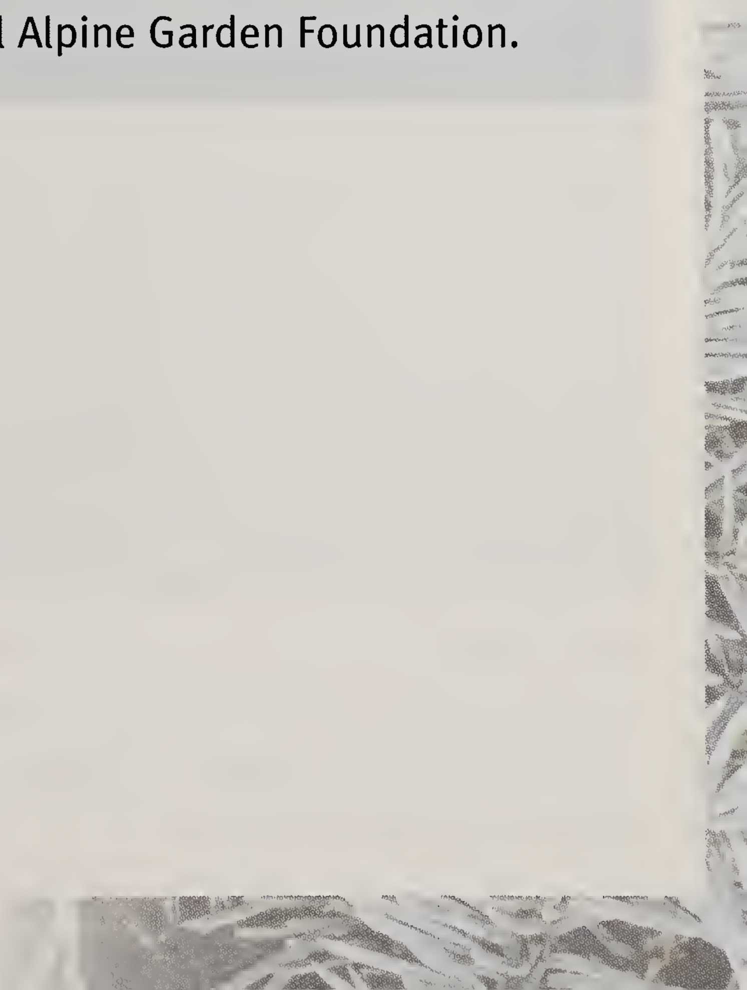
I learned quickly that the smaller creatures have an acute addiction to Icelandic poppy buds (*Papaver nudicaule*) and petunias. I find it best not to grow them. I stuff raw chicken skin in fresh mole and vole holes. How do you know the holes are fresh? Look for a straight ridge just below the ground surface and smash it with your foot. It is an active tunnel if it is soon rebuilt. The rabbits are fed alfalfa cubes in a little feeding station on the outer fringes of the garden. I was amazed that this does not seem to encourage more rabbits. I feed the chipmunks, squirrels and ground squirrels bird seed. They seem to like it more than the birds do. I have one chipmunk with no tail that has been coming every summer for three years.

A word of caution should be noted here. Bears love bird seed and they covet sugar water. I know this because one night I walked out onto my porch and was stopped cold when I saw a huge bear on its hind legs sucking the sugar water out of my hummingbird feeder. He had already destroyed the seed feeders. Bears do not eat your flowers, but they sure can trample them to death. Always bring your feeders in before dusk. This is especially important in the spring and fall when bears are their hungriest. They also love crabapples and can destroy a tree with three paws tied behind their backs.

All this seems to work for me. However, one day in a fit of domesticity I baked a peanut butter pie, placed it in the produce drawer in my refrigerator and left to do my volunteer work at the Betty Ford Alpine Gardens. The sight when I got home was indescribable. A slightly open window was all that was needed for forced entry into my kitchen. A mother bear and her two cubs decided to play *Goldilocks and the Three Bears* by paying my house an unwelcome visit, only porridge is not what they ate. It was not until they returned later that afternoon for "seconds" that the culprits were revealed. They wrecked my kitchen, eating everything in sight, including my pie, which had not previously been in sight. Scattered about my kitchen were the remains of apples, tomatoes, milk, butter, cinnamon bread, and a pie pan licked clean. I know that pie was what drew them to my house on this particular day.

My cat, Derrick, refused to come upstairs to the kitchen for the next three days.

AUTHOR BIOGRAPHY
Barbara DeVoe, a master gardener, grows orchids in Florida. Her prize winning alpine garden in Vail has been featured in *The Denver Post* and *Sunset Magazine*. DeVoe volunteers at the Betty Ford Alpine Gardens, co-chairs The Vail Valley Festival of Flowers garden competition and serves on the board of the Vail Alpine Garden Foundation.



Trees and shrubs typically provide the "backbone" of a landscape design and are an integral part of many, but not all, of the mountain environments that lie below timberline. In many cases, mountain forests are popular sites for mountain homes. Frequently trees are cleared in order to nestle a residence into such forests. However, the danger of forest fires, a natural part of forest ecology, should caution and guide all mountain residents in their landscape layout and strategy.

Conifers

Conifers have a natural association with the peaks and ranges of the Rocky Mountain region and have evolved to withstand and shed the weight of winter snow. In many cases, only one or a few species predominate in a particular region or locale. When choosing the best conifer to plant in your mountain landscape, consider the altitude at which you live and whether the microclimate where you reside is dry or moist. Generally speaking, pines will survive in drier locations than will spruce and fir trees. Different species of pine are associated with various altitudes.

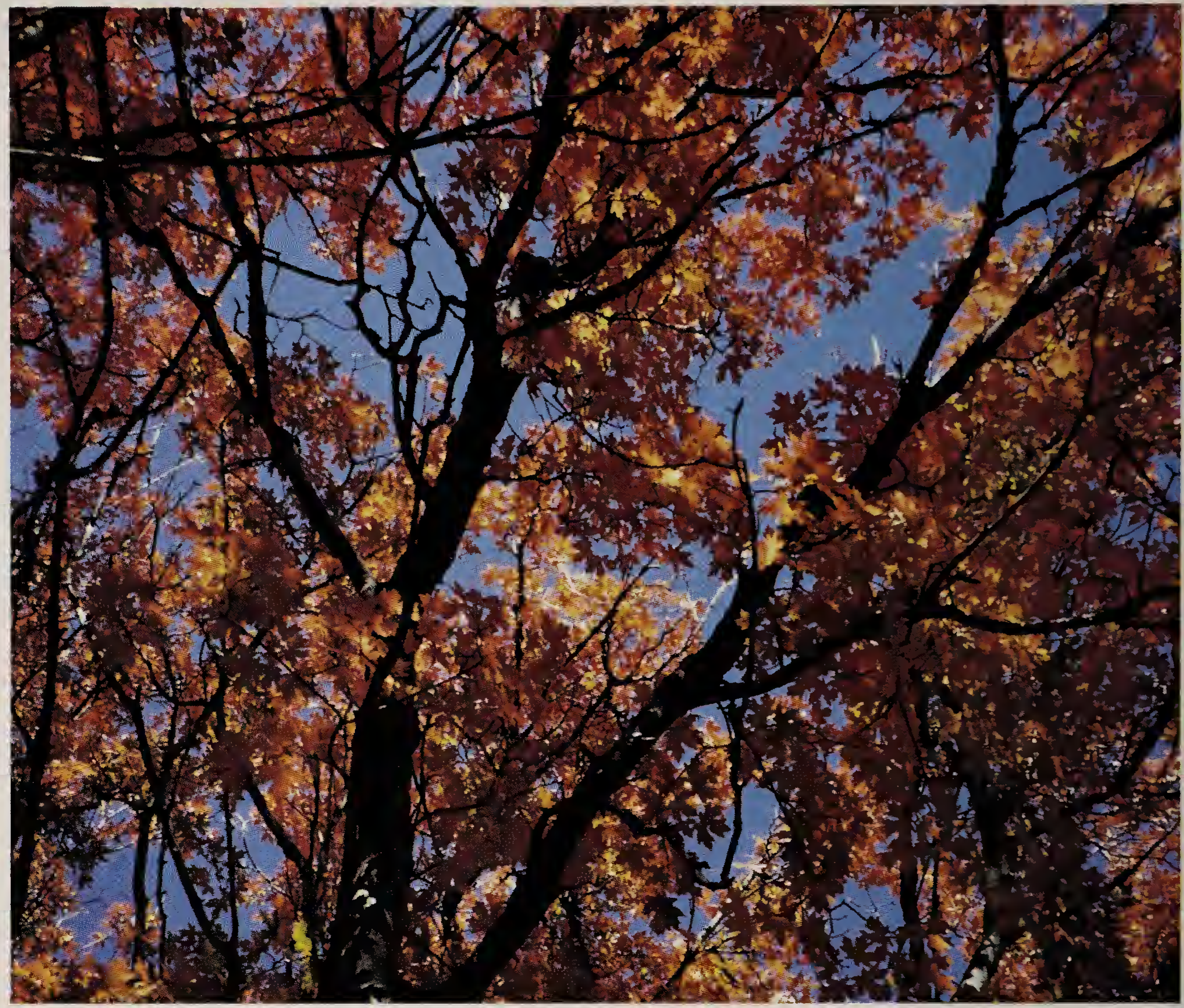
The Rocky Mountains are rich with native conifer species. Some beautiful non-native conifers and dwarf conifer cultivars will also grow at high altitudes.

Suggested Conifers:

Abies concolor — white fir
Abies fraseri — Fraser's fir
Abies lasiocarpa — subalpine fir
Juniperus communis — common juniper
Juniperus monosperma — one-seed juniper
Juniperus osteosperma — Utah juniper
Juniperus sabina 'Tamariscifolia' — tammy juniper
Juniperus scopulorum — Rocky Mountain juniper
Picea abies — Norway spruce
Picea engelmannii — Engelmann spruce
Picea glauca — white spruce
Picea omorika — Serbian spruce
Picea pungens — Colorado spruce
Pinus aristata — bristlecone pine
Pinus cembra — Swiss stone pine
Pinus contorta ssp. *latifolia* — lodgepole pine
Pinus edulis — pinyon pine
Pinus flexilis — limber pine
Pinus mugo — mugo pine
Pinus ponderosa — ponderosa pine
Pinus strobus — eastern white pine
Pseudotsuga menziesii — Douglas fir

By Marty Jones and Ken Slump

Trees and shrubs provide a garden's background. *photo: Marty Jones*



Acer grandidentatum

photo: Chris Hartung

Deciduous Trees

Extensive deciduous forests are less common at higher elevations except for the regionally ubiquitous aspen. However, a number of large and small native deciduous tree species are found in the plant communities associated with drainage areas, streams and wetland areas. In addition to natives, several of their close relatives and a few ornamental species can thrive at higher elevations.

Suggested Deciduous Trees:

Acer glabrum — Rocky Mountain maple
Acer grandidentatum — bigtooth maple
Alnus tenuifolia — mountain alder
Betula fontinalis — water birch
Betula papyrifera — paper birch
Betula pendula — European white birch
Fraxinus pennsylvanica — green ash
Malus spp. and cvs. — crabapples
Populus angustifolia — narrowleaf cottonwood
Populus tremuloides — quaking aspen
Populus x acuminata — lanceleaf cottonwood
Prunus americana — wild plum
Prunus virginiana 'Shubert' — Shubert or Canada Red chokecherry
Ulmus pumila — Siberian elm

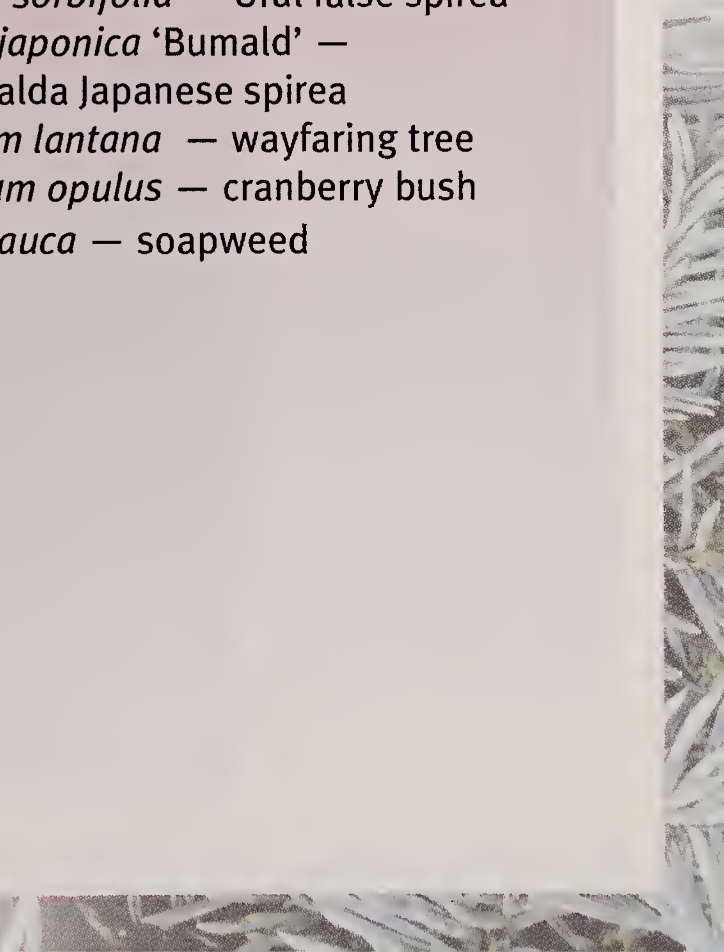
Shrubs

Deciduous and evergreen shrubs occur in both moist and dry habitats regionally. In some cases a particular species may occur over a wide range of habitats, its stature and vigor determined by the local microclimate. Others are more specific in their requirements and thrive in a limited area.

A surprising variety of both native and exotic hardy shrubs will survive at higher altitudes, and more could be tested. Some of the plants on this list fall into that nebulous category between "large shrub" and "small tree" that is perhaps best defined by the individual plant's growth habit and a gardener's pruning practices.

Suggested Shrubs:

Acer ginnala — Amur maple
Amelanchier alnifolia — serviceberry
Amelanchier canadensis — shadblow serviceberry
Arctostaphylos uva-ursi — kinnikinick
Artemisia cana — silver sagebrush
Berberis thunbergii — Japanese barberry
Caragana arborescens — Siberian pea-tree
Caryopteris x *clandonensis* — bluebeard
Chrysothamnus spp. — rabbitbrushes
Corylus cornuta — beaked hazelnut
Cotoneaster acutifolius — Peking cotoneaster
Cowania mexicana — cliffrose
Cytisus x *praecox* — Warminster broom
Daphne x *burkwoodii* 'Carol Mackie' — Carol Mackie daphne
Elaeagnus commutata — silver berry
Euonymus alatus — winged euonymus
Fallugia paradoxa — Apache plume
Holodiscus dumosus — rock spirea
Jamesia americana — waxflower
Lonicera involucrata — twinberry
Perovskia atriplicifolia — Russian sage
Physocarpus opulifolius 'Nanus' — dwarf ninebark
Prunus besseyi — western sand cherry
Prunus x *cistena* — purple-leaf sand cherry
Purshia tridentata — antelope bitterbrush
Quercus gambelii — Gambel oak
Rhododendron 'P.J.M.' — P.J.M rhododendron
Rhus aromatica 'Gro-Low' — Gro-Low fragrant sumac
Ribes alpinum — alpine currant
Rosa foetida 'Persiana' — Persian double yellow rose
Rosa rugosa 'Belle Poitevine' — Belle Poitevine rugosa rose
Rosa woodsii — western wild rose
Rubus deliciosus — boulder raspberry
Salix exigua — sandbar willow
Salix purpurea 'Nana' — dwarf Arctic willow
Sambucus canadensis 'Aurea' — golden elder
Sambucus pubens — red-berried elder
Shepherdia argentea silver buffaloberry
Sorbaria sorbifolia — Ural false spirea
Spiraea japonica 'Bumald' — Bumalda Japanese spirea
Viburnum lantana — wayfaring tree
Virburnum opulus — cranberry bush
Yucca glauca — soapweed



top: Ribes aureum

photo: Jim Borland

left: Arctostaphylos uva-ursi

photo: Marty Jones

Rosa woodsii

photo: Jim Borland

Non-native woody plants may be grown in many locations. Adventurous mountain gardeners have introduced a remarkable array of trees and shrubs into the landscapes of some mountain communities, yet it remains difficult to cultivate a number of popular species at higher altitudes even though the winter temperatures in many locations are well within the plants' tolerance. One might suspect the high altitude soils or intense sunlight as problematic, but it is most likely the short growing season that limits the adaptability of many types.

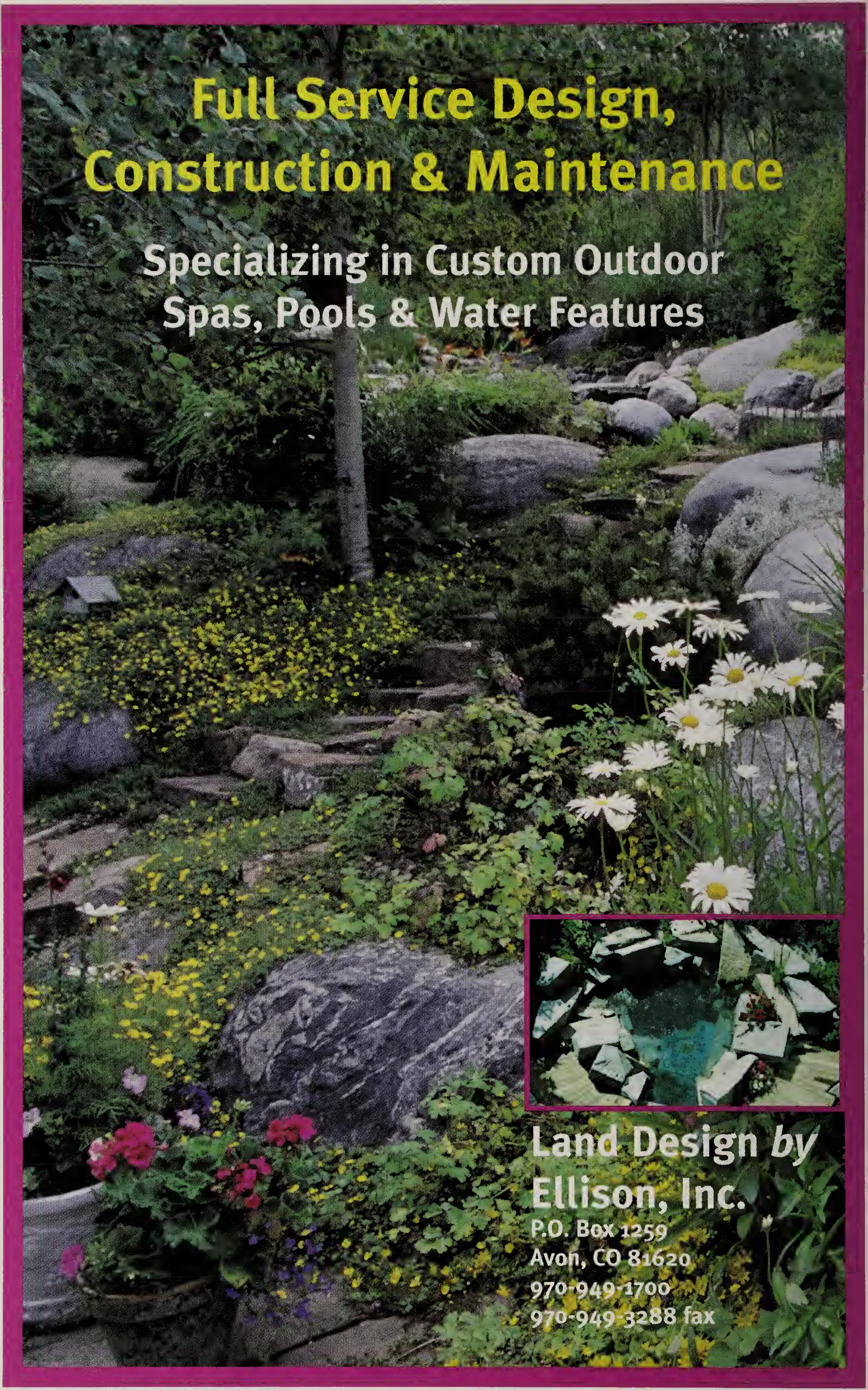
Again, site analysis should guide your tree and shrub selection. Is your area wet or dry? Does it have snow cover all winter long? Is wind a factor? Does your site receive considerable shade from nearby peaks or rock formations? Are browsing animals a problem? Knowing the habitat of your mountain "neighborhood" and the microclimates of your site will enable you to choose woody plants that will grow in harmony with the surrounding environment and have a good chance of survival.

Remember that the higher your altitude, the narrower your selection of woody plants will be. The preceeding lists include some of the more frequently grown trees and shrubs and may serve as a guide for mountain residents at elevations between 7,000 and 8,500 feet.

AUTHOR BIOGRAPHIES

Marty Jones of Edwards, CO, is founder and principal of Colorado Alpines, Inc., a nursery and landscaping business. He is co-founder and designer of the Betty Ford Alpine Gardens in Vail.

Ken Slump of Denver, CO, holds a masters degree in horticulture from Colorado State University and is plant records manager at Denver Botanic Gardens. He has volunteered at the Betty Ford Alpine Gardens in Vail.



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Window on the Tropics

Mountain, Plain and Garden
The Magazine of Denver Botanic Gardens
Volume 55, Number 2, Fall 1998

Welcome to the tropics

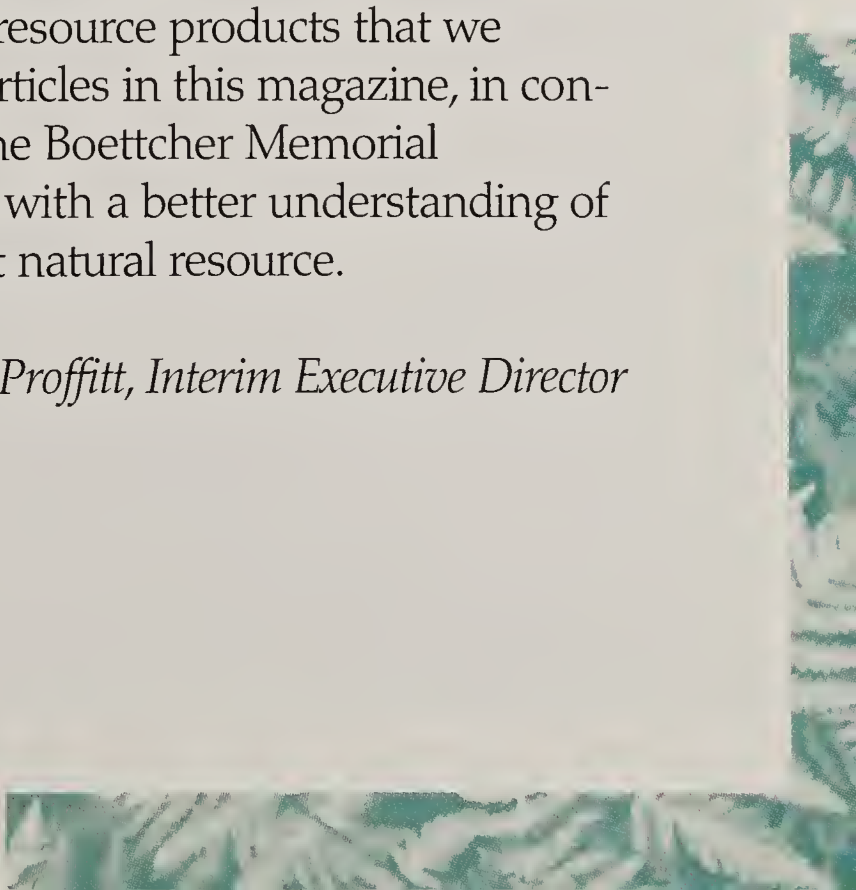
Greetings and welcome to this special issue of *Mountain, Plain and Garden*, the magazine of Denver Botanic Gardens. This issue has been written to commemorate the much anticipated reopening of the Boettcher Memorial Conservatory at Denver Botanic Gardens. The Conservatory is an ornamental greenhouse that provides the conditions necessary to grow and display tropical plants that are not hardy in the semi-arid climate of Colorado.

Originally dedicated in 1966, the exhibit has undergone a complete internal renovation to improve the climate for plant growth and to make the facility accessible to physically challenged visitors. Beginning in February of 1997, major portions of the electrical and mechanical systems were replaced to dramatically improve control of the facility's humidity and temperature. The exterior of the Conservatory, which has become known as the Gardens' signature architectural feature, will remain unchanged.

With its improved growing conditions, the Conservatory will offer a much more diverse and beautiful display of plants common to tropical forests from throughout the world. In light of the increasing destruction of tropical forests, educating people about tropical plants and ecosystems has become critical. The plants and their interpretation provide Denver with one of the most exciting and compelling displays of tropical plants and ecosystems anywhere outside the tropics.

We'd like to thank our fine group of authors for lending their expertise to explain the biological aspects and diversity of tropical forests, as well as the wide array of resource products that we enjoy. We hope that the following articles in this magazine, in conjunction with a visit (or many!) to the Boettcher Memorial Conservatory, will help provide you with a better understanding of perhaps the world's most important natural resource.

John B. Proffitt, Interim Executive Director



Pam Rathke

A lush rain forest surrounds a lake off the Amazon River in Peru.

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Julie Behrens, Managing Editor
Kenneth W. Slump, Jr., Consulting Editor

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Inside covers: *Musa zebrina*, blood banana, by Gary Davis.

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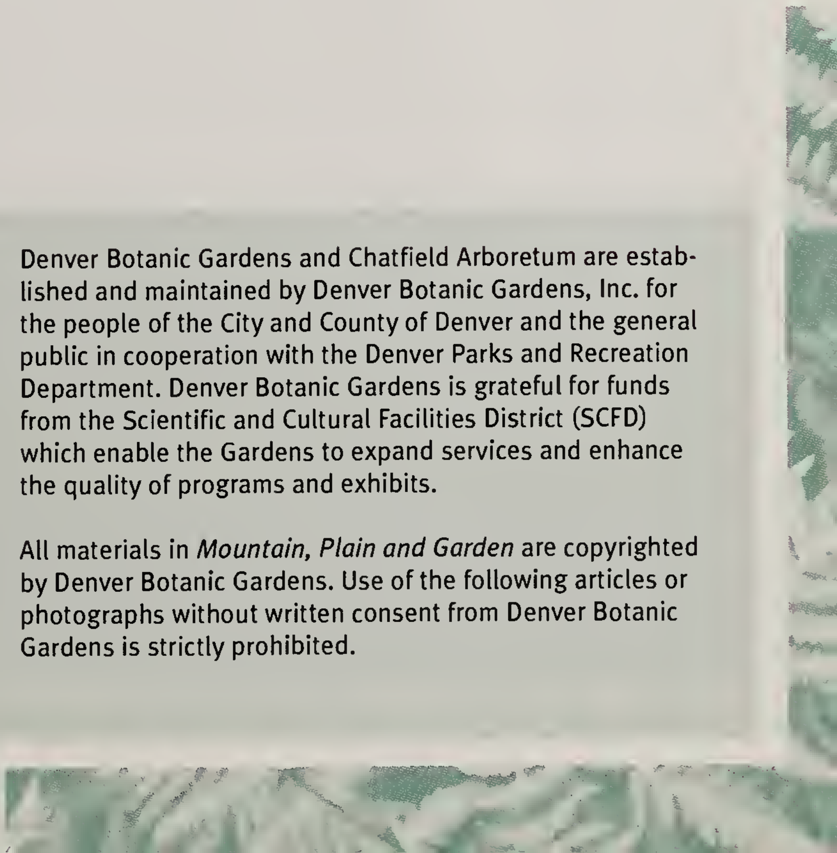
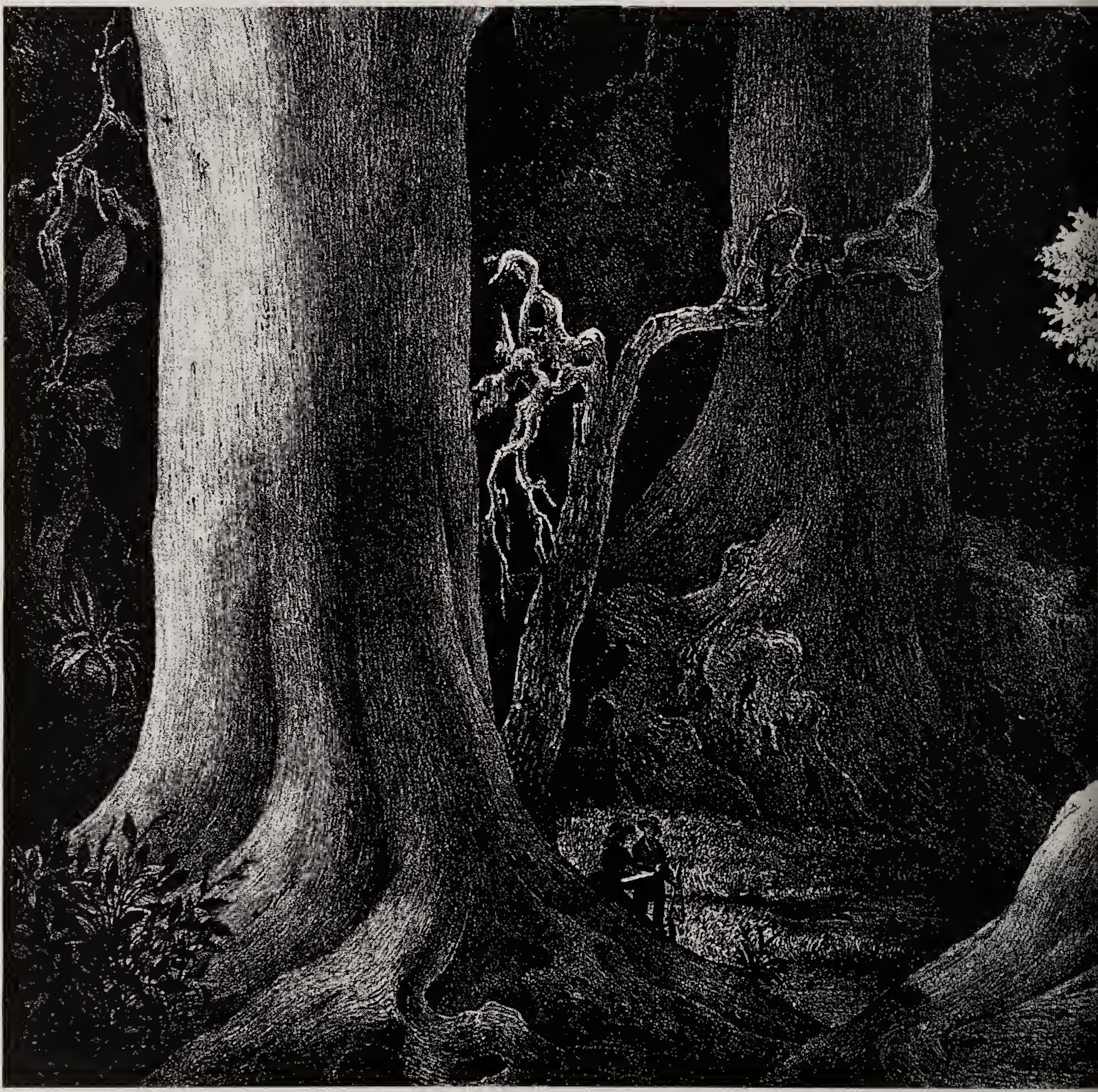


CHAPTER ONE

TROPICAL FOREST BIOLOGY



Source: The Tropical Rain Forest, by Marius Jacobs

Drama and myth about the rain forest sprang from exaggerated depictions such as this one created by B. Mary in 1836.

WHAT IS A TROPICAL FOREST?

By Kenneth W. Slump, Jr.

The major parts of several continents which lie between the tropics of Cancer and Capricorn comprise the tropics, an important portion of the earth's land mass. Perhaps the most significant fact about these lands is how very diverse they are. The topography in the tropics varies from coastal plains to rugged mountains. Tropical climates range from very wet rain forests to arid deserts.

The biologically complex rain forest is perhaps the most publicized yet least understood tropical habitat. Much drama and myth about it was created through the tales of early European travelers whose descriptions of the sights they saw in rain forests provided fuel for vivid imaginations. Certainly the examples of flora and fauna that were returned to Europe from these regions did little to dispel this image as they were often frighteningly dissimilar to the plants and animals with which the residents of the Continent were familiar. For centuries the rain forest was the stuff of fable and adventure, and more recently, its swift demise the cause for global alarm."Save the rain forest"has become such a popular phrase in the environmental lexicon that many of us have forgotten or failed to recognize that there are many different types of tropical forests.

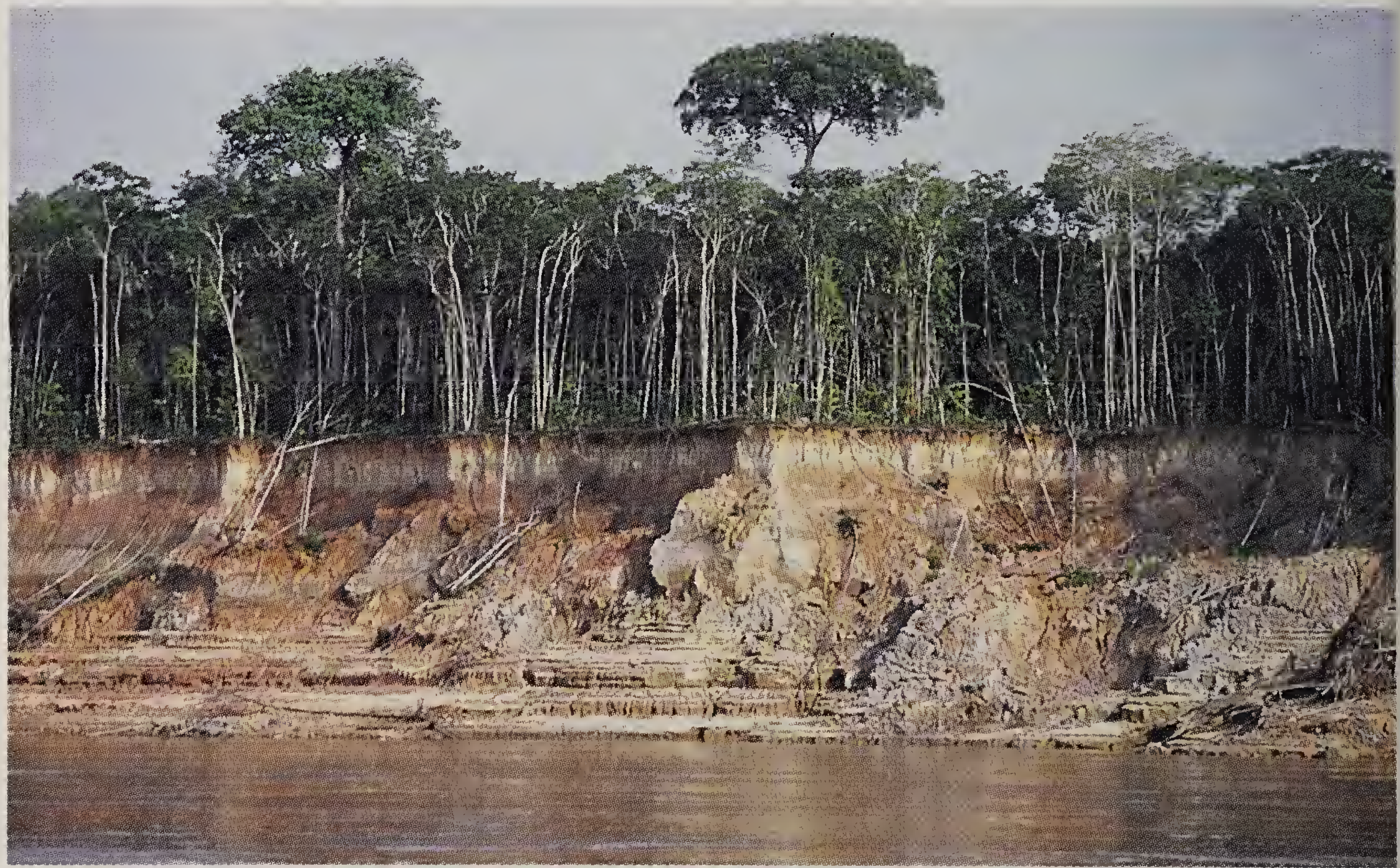
Tropical forests are not necessarily the impenetrable tangle of vegetation that was promoted in old adventure novels and early Hollywood films. Certainly there are locations, particularly along rivers, that can be difficult to penetrate, but in many tropical forests it is comparatively easy to move about.

Tropical forests are not always as dark and steamy as most of us envision. Breezes across the branches of treetop canopies create an everchanging mosaic of shifting light patterns through the layers of vegetation below them.

Tropical forests are not the dank and dismal haunts of myriad poisonous insects and reptiles, as well as ferocious beasts, lurking in the darkest corners in search of human prey. Yet, without a doubt, tropical forests harbor an unfathomable diversity of as yet undiscovered plant and animal species that makes the urgency of the quest to discover new life forms on other planets a point to ponder. Still, the tropical rain forest does contain aspects of its popular legend and can provide a basis for comparison with other tropical climates.

It is important to note that there is no universally accepted classification system to apply regarding ecological systems. Most models are based on plant communities because they are considered to be more stable than those of animals (which frequently range through several biomes). Average annual temperature and precipitation are the main factors considered, but differences in soil types and seasonal climatic patterns are but two of several additional criteria that may come into play.

The term tropical rain forest is just 100 years old; first applied by the nineteenth century German naturalist A. F. W. Schimper. His 1898 treatise on plant geography described four types of tropical forests based on progressively drier, more seasonal climates: rain forest, monsoon forest, savanna forest and thorn forest. Two drier trop-



Kirk Johnson

Cutbank of the Amazon River in Fonte Boa showing a cross-section of a typical rain forest and the underlying bank.

ical climates unable to support woody vegetation he called tropical grassland and desert. This system provided the basis for most of the classification schemes that followed, although most subsequent systems have further divided Schimper's six basic groups. Even under the best of these schemes, classifications tend to blur and are transitional at their boundaries.

Rain forests in the tropics are found primarily at lower altitudes, from sea level up to perhaps 3000 feet in elevation. The largest of these occur in the Amazon and Orinoco river basins of South America. Other important rain forest locations include Central America, the Zaire Basin of Africa and the Indo-Malayan region.

Constant high temperatures typify the tropics and by definition, any climate with a mean temperature of 65° F or higher during the coldest month may qualify as tropical. (This eliminates some mountain areas that fall within the tropics which have somewhat cooler average temperatures.) Temperatures in the tropical rain forest are consistently high throughout the entire year. The temperature variation is so small that, in fact, there is a greater difference in the temperature extremes from day to night than there are from the warmest season to the coldest.

Moisture, however, is the most dramatic factor in a rain forest. At least 100 inches must fall throughout an entire year for a rain forest to exist. (By comparison, Denver's annual precipitation is usually less than 15 inches per year.) Periods without rain are brief and infrequent, lasting only a few days or weeks.

Trees in tropical rain forests are lofty and evergreen. The tree canopy towers from 100 to more than 160 feet above the ground. It is comprised of a mixture of trees whose differences in crown shape and color are easy to discern from the air. So many kinds of plants grow in the tropical rain forest that it is said there are more species in just a few acres of rain forest than there are in the entirety of Europe. The trees are shallow rooted and many have buttressed roots. Sporadically, very tall trees, called emergents, protrude above the canopy. Some of these trees reach heights of well more than 200 feet and their presence gives the canopy, when viewed from above, an uneven appearance.

Although tropical rain forest plants are evergreen, most do not grow continuously. New growth frequently occurs in flushes and the new foliage is often colorful. For most species, flowering and fruiting occur annually. Leaf fall varies by species and is often heaviest after a new flush of growth.

Woody vines, known as lianas, proliferate, scrambling from tree to tree in search of light. Epiphytes—plants that obtain their moisture and nutrients from the air, rain and decomposing plant debris while clinging to another plant for support, abound. Although many exotic blossoms and colorful foliage plants originate in such forests,

*Three-toed sloth (*Bradypus variegatus*) in the Brazilian Amazon. Sloths have adapted to live most of their lives in the rain forest canopy, eating only leaves. They belong to a group of animals with a South American fossil record that stretches back 60 million years.*

it is a mistake to envision the rain forest as a gaudy floral display. Still, it is written that the sheer profusion of vegetation in tropical rain forests is staggering. The canopy zone has the greatest diversity and teems with plant and animal life in this biome as nowhere else on earth.

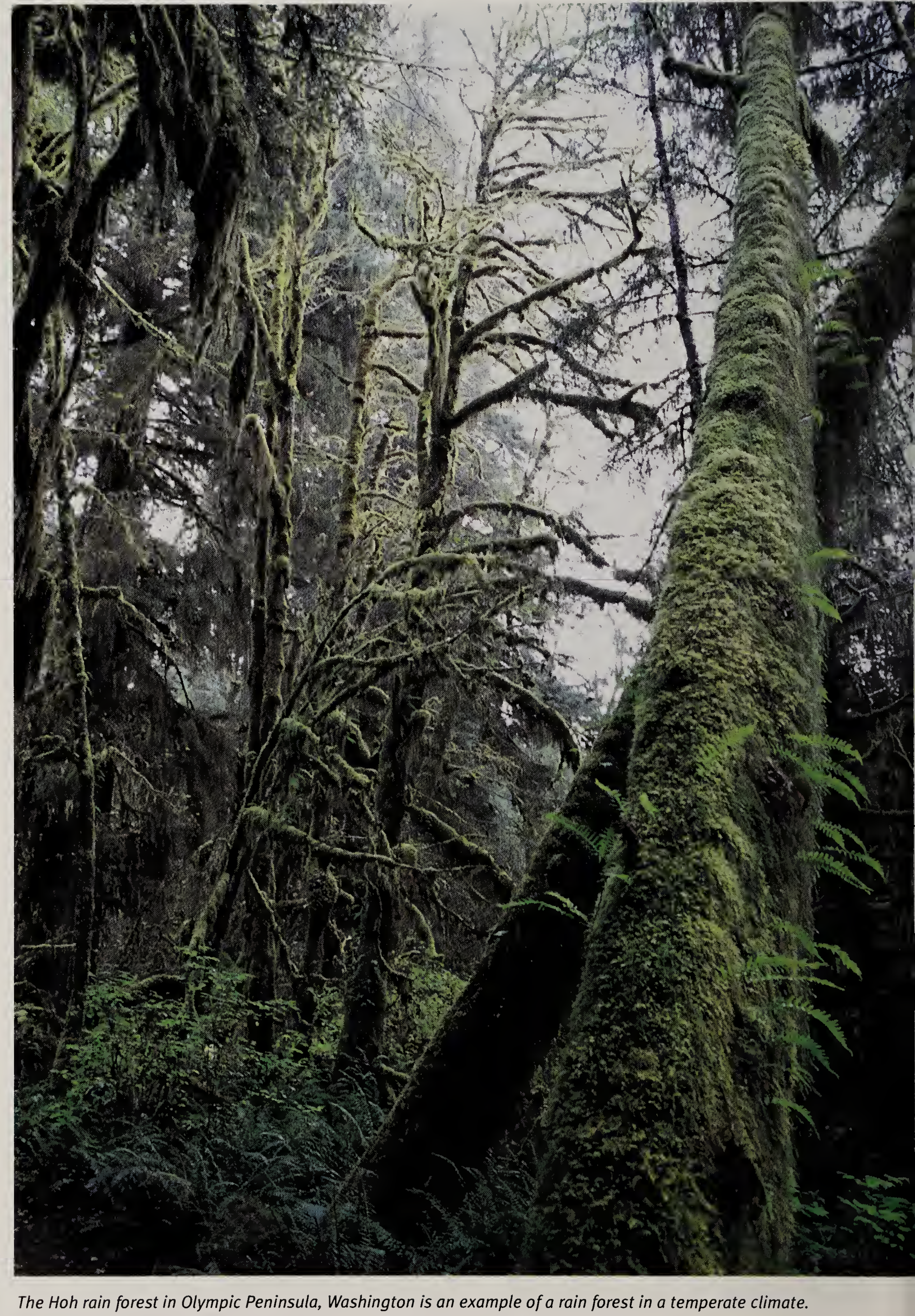
Tillandsia bulbosa *is a long-flowering epiphyte.*

The rain forest is rich with animal life, but most visitors to one would not likely encounter very many of them. Many animals that live in the rain forest have adapted to survive in a particular zone or niche there. Many more non-flying animals are arboreal in habit in the rain forest compared to the temperate forest. Probably half of the rain forest mammal species live in the forest canopy. Many of the animals that dwell in the rain forest are nocturnal. A large number of mutually dependent and unique plant and animal relationships have developed in the rain forest environment.

How many kinds of animals live in the rain forest? Among larger animals, mammals and birds, there are probably twice as many tropical species as temperate ones. Insects and invertebrates have been less studied in the tropics, but if the same ratio holds true, the tropics in their entirety may hold between two and three million animal species, many of which are as yet undescribed insects.

Trees in the rain forest sometimes fall due to weather-related disturbances or may die and topple from old age, thus creating gaps in the rain forest canopy. These gaps allow streams of light to invade the shady understory that normally receives a mere 2% of the light from above. The dimension of such gaps varies depending on the size of the tree that falls, and how many other trees it takes down with it. Gaps initiate a new succession of plants which rapidly flourish and grow that would otherwise be unable to compete under the shade of the canopy.

Tropical forests with ample rainfall, yet with several drier months on a regular basis (months with about two inches of rainfall or less), are called monsoon forests, or, outside of Asia, tropical seasonal forests. Trees in the monsoon forest are not quite as tall as those in the tropical rain forest and the canopy tends to be more even. Numerous tree species in the monsoon forest are deciduous, if even briefly. There are fewer climbing plants and epiphytes in such forests and the number of species is somewhat reduced. Within the last 25 years, the term tropical moist forest has been used to include both rain and mon-



The Hoh rain forest in Olympic Peninsula, Washington is an example of a rain forest in a temperate climate.

soon tropical forests. Although they are biologically different, they have some similar characteristics and their boundaries are often indistinct.

Within the parameters of the tropical moist forest are a number of more specifically defined kinds of forests that have received delineation and study by various scientists. Tropical semi-evergreen rain forest, montane rain forest, heath forest, freshwater swamp forest and peat swamp forest are among these.

Schimper's third type of tropical forest, the savanna forest, is now more commonly known simply as savanna. It is a tropical grassland with trees. The trees are scattered, their ranges controlled by soil conditions or periodic fires. Savanna climates are moderately dry, with summer rainfall that ranges from roughly 20 to 60 inches. Most of the tree species are deciduous during the dry season. The savanna climate is extensive across Africa, Southeast Asia and South America.

Thorn forests are also widespread across the tropics, found primarily on the margins of equatorial tropical and sub-tropical semi-arid regions. Rainfall in such areas rarely exceeds about 27 inches annually, again, occurring primarily during the summer season. Trees with open growth habit, primarily acacias, form woodlands with an associated understory of cacti, other succulents and grasses. As the name implies, many of these trees and shrubs are armed with spines.

Of the tropical forests, it is the moist forests (rain forest and monsoon forest) and their subsidiaries, and not the dry forests (savanna forest and thorn forest) that are the primary object of global concern. This is because they are so species rich and yet face rapid destruction before researchers can even explore and catalogue all of their wonders. It is estimated that of the approximately 250,000 flowering plant species on earth, perhaps two-thirds, or 170,000, occur in the humid tropics.

Despite the mystery that the tropical moist forest continues to hold for Western scientists, we should acknowledge that man has lived in close association with tropical forests for millennia. The essentials of life were provided in and near their borders. Industrialization and modern medicine have made life in the tropics much less dangerous than it once was and consequently life expectancies and populations in the tropics have risen dramatically. Technology has made it possible to quickly clear forests that until very recently seemed indestructible. The outcome that will result from modern pressures is the real drama and peril for the remaining moist tropical forests.

AUTHOR BIOGRAPHY

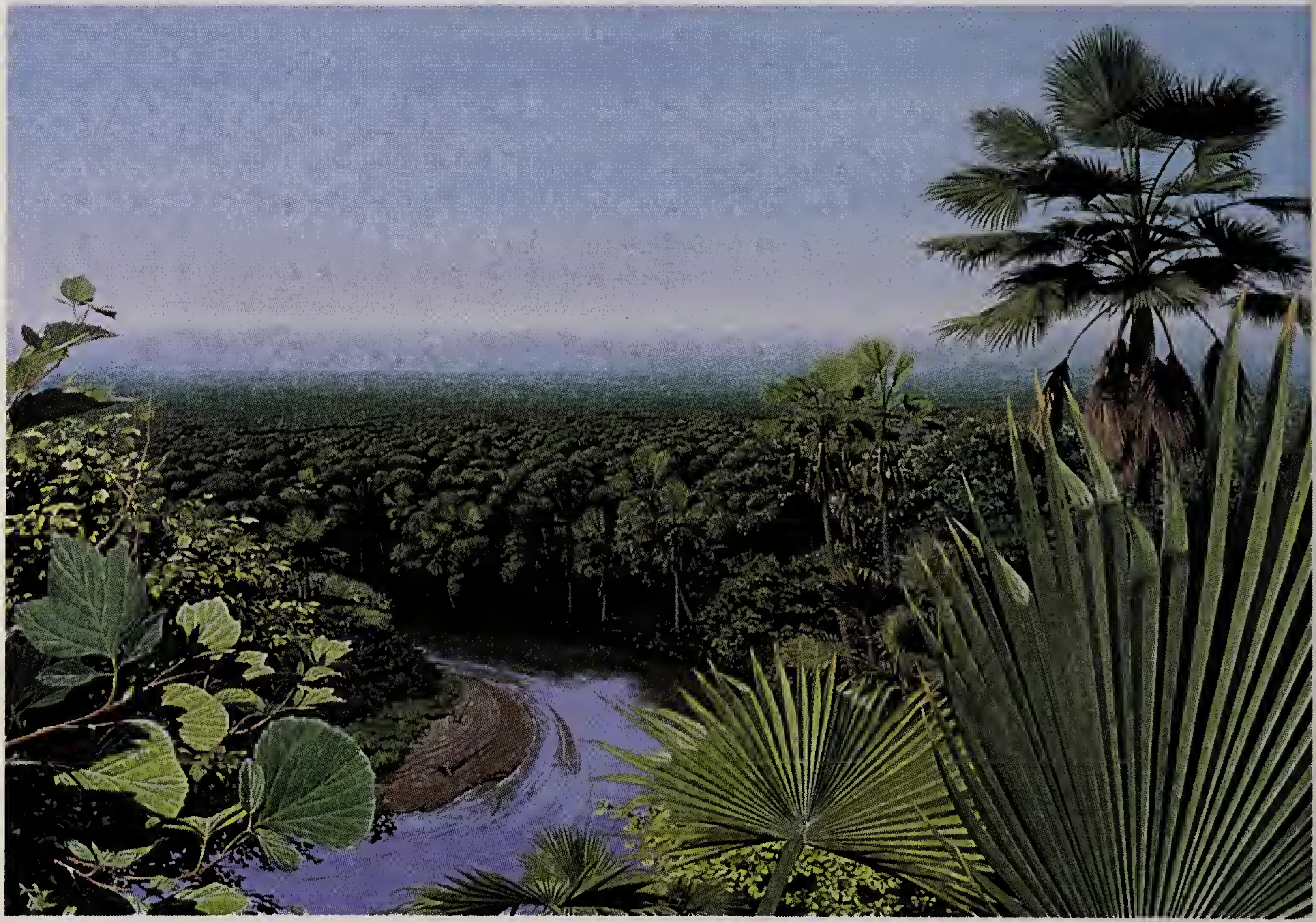
Ken Slump has degrees in horticulture from Colorado State University and is Plant Records Manager at Denver Botanic Gardens. He is a student judge at the Rocky Mountain Judging Center of the American Orchid Society.

PREHISTORIC TROPICAL RAIN FORESTS OF COLORADO

With the opening of the newly refurbished Boettcher Memorial Conservatory at Denver Botanic Gardens, visitors can now wander through a space full of plants from tropical forests. For many, it will be their first time in a tropical forest and the experience will be very unfamiliar. The hot, moist air and riot of giant leaves is an experience that you cannot have in any of Colorado's modern forests or prairies.

The contrast between Denver's vegetation and the contents of the Conservatory will be one of the main things that make the visit so interesting. Surprisingly, this contrast once did not exist. The city of Denver is built on bedrock that contains the remains of fossil rain forests. Between 48 and 68 million years ago, this area was densely forested and for some of this time, the forests had many of the features that we find in modern tropical rain forests.

At the Denver Museum of Natural History, we are working to excavate and understand Colorado's ancient rain forests. To find fossils you must first find rocks that were once mud and sand. Denver is built on a large geologic structure known as the Denver Basin. To visualize the basin, imagine an onion that has been sliced in half. The flat surface is analogous to the generally flat area that stretches



Reconstruction of the Denver International Airport fossil site as it looked 65 million years ago when it was a low diversity rain forest with abundant palm trees. Painting by Donna Braginetz.

By Kirk R. Johnson, Ph.D.

from Denver to Colorado Springs to Limon near the Kansas border. The nested concave segments that make up the onion lie below the surface and extend down more than two miles. The distance from Denver to Limon is 70 miles so this is an oddly flattened onion, more that 70 miles wide and 2 miles thick.

The layers of rock that are analogous to the segments of the onion are known as formations. One of the basic rules of geology is that the older layers lie below the younger layers. The sliced onion displays a bulls-eye when viewed from the top with the highest layers in the middle of the onion and the lower ones around the edge. Thus the younger rocks (a mere 35 million years old) are exposed in the middle of the Denver Basin in the land east of Castle Rock. The older layers (as much as 70 million years old), underlying Boulder, Limon and Colorado Springs, are exposed around the edge of the basin.

Kirk Johnson

Denver Museum of Natural History volunteer John Shinton at the Denver International Airport construction site with the imprint of a fossil palm leaf.

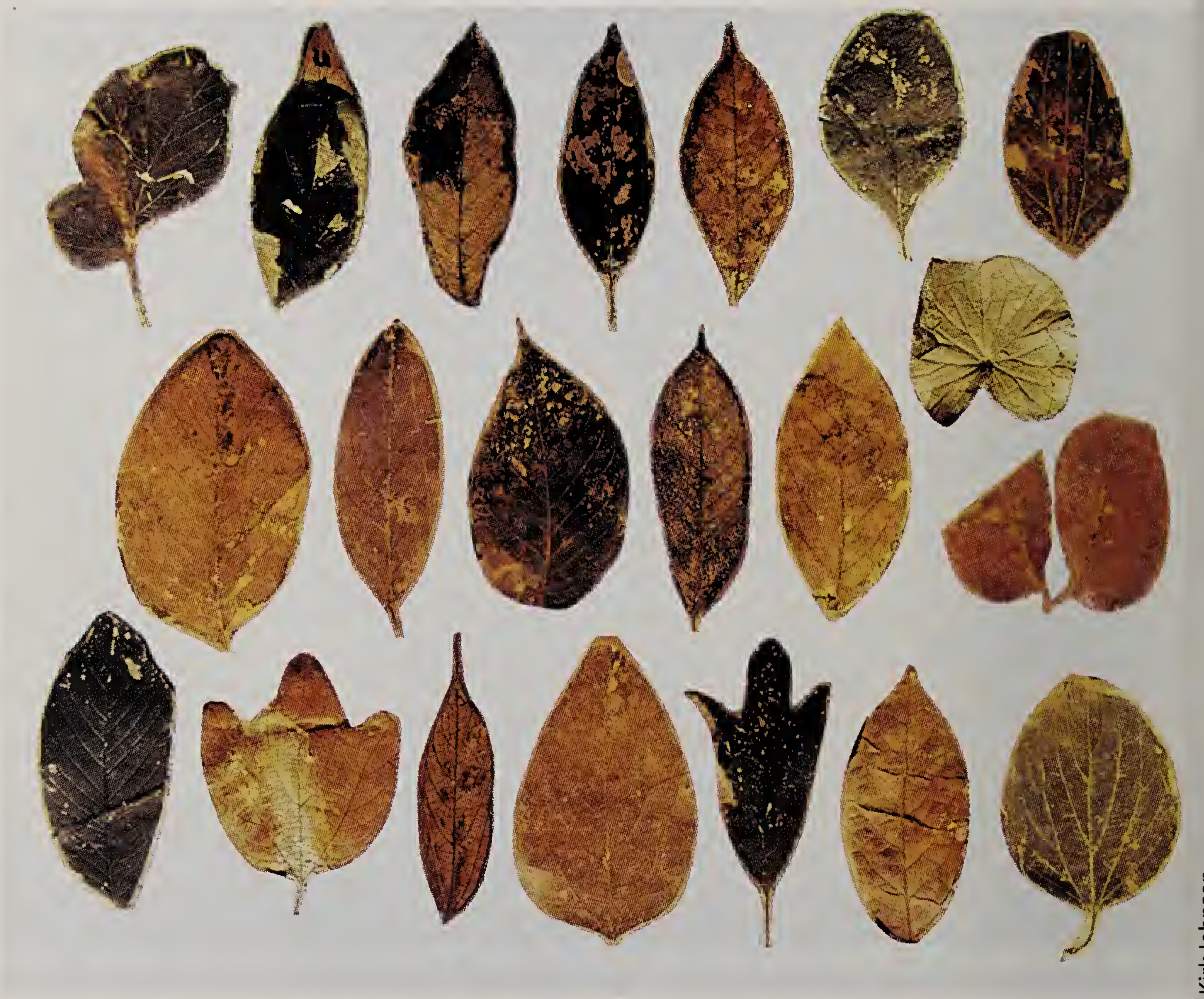
These layers of rock were originally laid down as mud and sand at the bottom of ancient streams, rivers and lakes and some of these bodies of water were found in dense forests. Leaves, branches, fruits and seeds fell from the forests into the water and were buried in the mud that later hardened to stone. Dig a hole in Denver and you will encounter this stone and if you are lucky, you will find the remains of these forests.

As the Paleobotanist at the Denver Museum of Natural History, it is my job to hunt for Denver's botanical history. This has been very easy in the last decade due to the amount of economic growth in the Denver metropolitan area. Lots of people are digging holes — holes to build a new airport, a new baseball stadium, new roads and thousands of new homes and businesses. Every one of these holes is a potential fossil site.

In 1990, during excavation for the construction of Denver International Airport (DIA), workmen found imprints in stone of what they thought were giant fish tails. They brought the fossils to the museum to be identified. What they thought were fish tails were actually the bases of giant palm fronds. Palm trees grow in the tropics today. They don't grow where the ground freezes in winter.

We spent much of 1991 at the DIA excavation and found hundreds of palm leaves and the remains of about twelve species of flowering plants, some with leaves as large as dinner plates. One of the palm fossils was six feet wide and eleven feet long! In the foundation of Concourse B, we found a coal seam with 47 layers of volcanic ash. Dr. Glenn Izett of the United States Geological Survey was able to measure the radioactive argon in the ash and calculate the age of the rocks at the airport as 65.7 million years old.

From the size of the leaves and the presence of palms we were able to estimate that rainfall and temperature were much higher then than they are now but the climate was not fully tropical. One of the most distinctive features of modern tropical rain forests is a very high level of species diversity. Some tropical forests in South America and Indonesia have as many as 300 tree species in a single hectare (2.47 acres) of forest! So the DIA forest was warm, wet and not very



Kirk Johnson

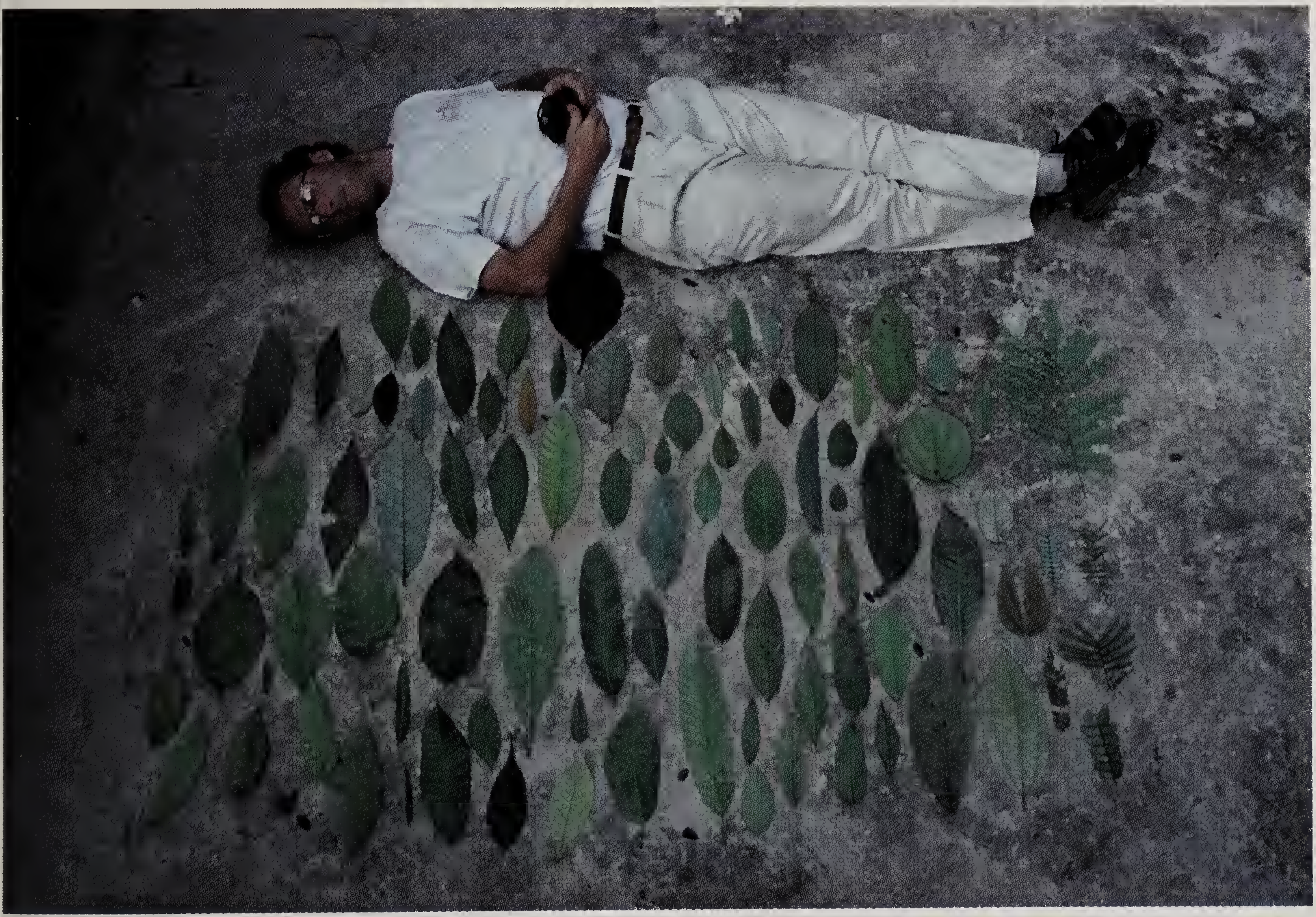
Fossil leaves from the Castle Rock fossil site showing leaf shapes typical of modern tropical rain forest plants.

diverse, while modern tropical rain forests are hot, wet and very diverse.

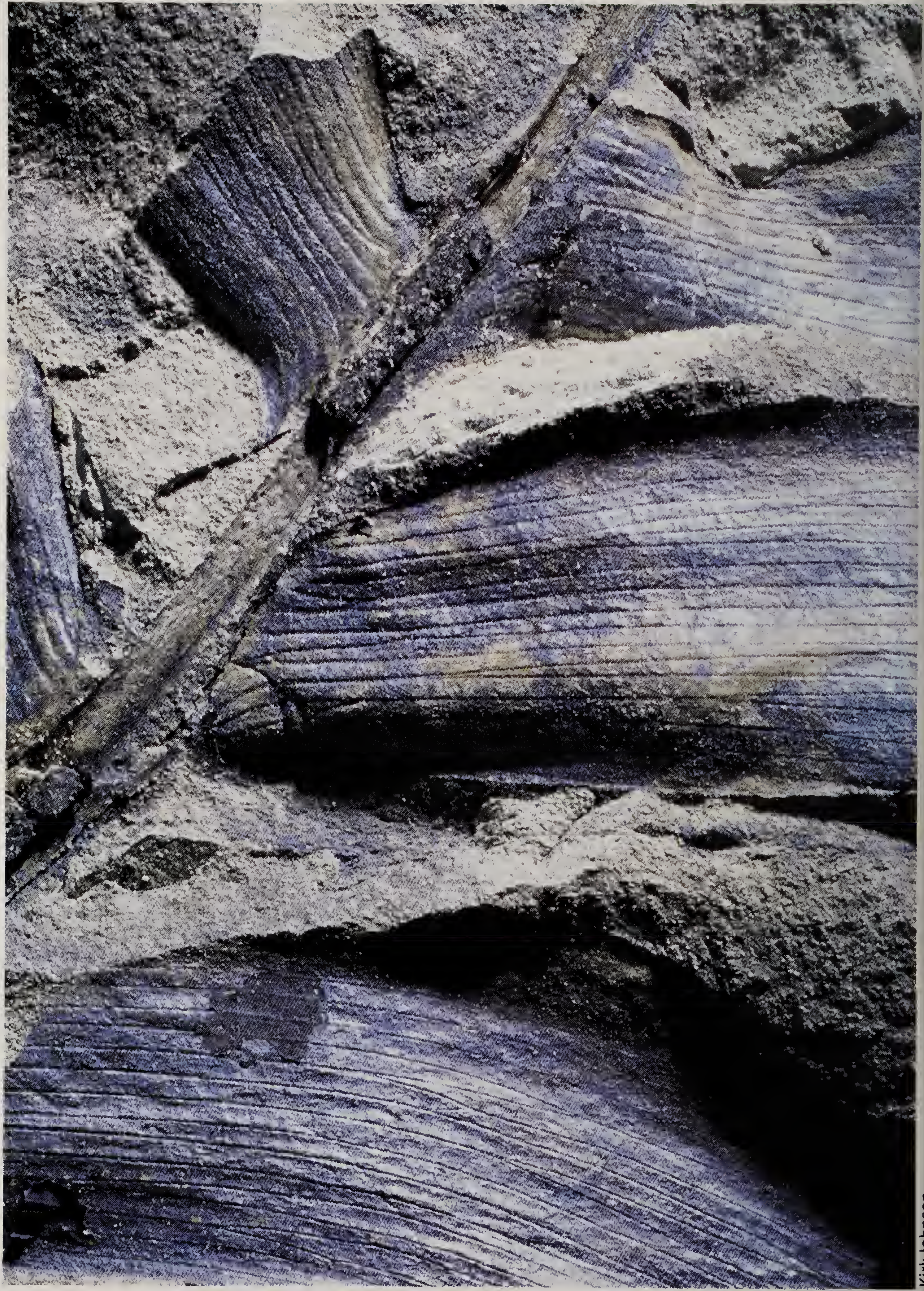
A few years later, Steve Wallace from the Colorado Department of Transportation found an amazing fossil site along the east shoulder of I-25 in Castle Rock. We have excavated this site since 1994 and have discovered a fossil forest that has many characteristics of modern tropical rain forests. This site has high species diversity and our roadside trench has yielded more than eighty different types of broad-leaved flowering plants.

Many of these leaves are the size and shape of leaves that grow in modern rain forests. A typical rain forest leaf is large (often longer than 8 inches), has a smooth margin, and an elongated tip known as a drip tip that functions like a gutter to run water off the surface of the leaf. Many of the Castle Rock leaves have all of these features. In addition, this site has produced a fossil of a cycad plant.

Some of the most unusual plants on display in the renovated Boettcher Memorial Conservatory are the cycads. These leathery-leafed stumpy specimens are often confused with palms but they are not flowering plants. They are gymnosperms and reproduce by seeds encased in colorful cones. There are 185 species of living cycads and all of them grow in subtropical or tropical areas in habitats ranging from tropical rain forests to dry scrublands.



Freelance journalist Bob Moore is pictured among leaves from the Brazilian Amazon to illustrate leaf shape and size.



Kirk Johnson

Fossilized cycad leaf from a fossil site in Castle Rock, Colorado.

The Castle Rock cycad is an amazing specimen because so much of it was preserved. We were able to retrieve the fossilized trunk, roots, 25 of the 3-foot-long fronds and even a seedling plant. This fossil is one of the most complete fossil cycads ever found and it is further evidence of Colorado's ancient rain forests. The age of the Castle Rock fossil site is still being researched but we are confident that it was a forest somewhere between 64 and 55 million years ago.

Fifty-five million years ago, the world was in a very warm period. There were no ice caps in the arctic and forests grew on Antarctica. Forests with tropical characteristics grew as far north as the Canadian border and crocodiles lived in what is now arctic Canada. Colorado was covered with rain forest.

Today the picture is considerably different. Colorado has cold winters and comparatively small amounts of annual precipitation. Coniferous forests cover the Rocky Mountains and the prairies are almost totally without trees. Two things have driven this change, the elevation of the Rocky Mountain region has increased and global climate has grown more seasonal. It's now cold and dry where it used to be warm and wet. The Boettcher Memorial Conservatory gives you a glimpse of what it is like to wander around in a modern tropical rain forest. It also gives you an idea of what the Denver area was like more than 50 million years ago.

AUTHOR BIOGRAPHY

Kirk Johnson has served as Curator of Paleontology at the Denver Museum of Natural History since 1991. He specializes in research of fossil plants from the Rocky Mountain region and, with Richard Stucky, authored Prehistoric Journey: History of Life on Earth. Johnson has a Ph.D. in Geology and Paleobotany from Yale University.

CANOPY RESEARCH OF TROPICAL FORESTS

Overhead, at a height, perhaps of a hundred feet, is an almost unbroken canopy of foliage formed by the meeting together of these great trees and their interlacing branches; and this canopy is usually so dense that but an indistinct glimmer of the sky is to be seen, and even the intense tropical sunlight only penetrates to the ground subdued and broken up into scattered fragments... it is a world in which many seem an intruder, and where he feels overwhelmed...

A. R. Wallace,
A Tropical Nature.
Macmillan, London. 1878.

E.O. Wilson has called forest canopies "the last frontier" of biological research on the planet. The tree tops have long eluded scientists and explorers because of the logistical difficulties of reaching the canopy and because of the challenges to collect data in these lofty heights. Only in the last decade have field biologists begun extensive exploration of this unknown world of plants, insects, birds, mammals and their interactions. These achievements are attributed to the development of several innovative and creative techniques that facilitate ascent into tree crowns.

Ideas about forest canopies had changed very little over the past 100 years until the 1970s, when biologists first adapted mountain-climbing hardware for ascending tall trees. Over the past ten years, a number of field methods have facilitated a better sense of understanding of this complex, above-ground ecosystem. In a scenario similar to coral reef ecology, with the 1960s advent of scuba diving, canopy biologists are using new techniques to quantify the species, their interactions and the attributes of this above-ground environment.

There are several reasons that canopy access has become a priority for many scientists. First, as rain forests continue to dwindle, the urgency of surveying the biodiversity in tree crowns challenges some researchers. There are arguably millions of as-yet-undiscovered organisms throughout forest canopies, some of which may contain important economic and medicinal products. By virtue of their complexity, tropical tree canopies reputedly house the largest diversity of terrestrial organisms. Second, canopy processes are essential to life on our planet as the canopy is the major site of production of energy via photosynthesis that fuels many aspects of global climate and other important functions. Third, many researchers admit to simple curiosity to explore this previously inaccessible region of forests. For example, how many orchids remain undiscovered in the upper regions of tree crowns? How many species of beetles exist? Which plants produce important toxins that can be utilized in medicine?

The first major breakthrough in canopy research was the application of technical mountain climbing hardware for ascending tall trees. Single rope techniques (termed SRT) allow

By Margaret D. Lowman, Ph.D.

Margaret Lowman

Using ropes to climb a kapok tree in a Peruvian Amazon forest.

scientists to reach the mid-canopy with ease, and hang suspended to make observations of pollinators or to count epiphytes. But ropes have two obvious limitations: they are not conducive to collaborative work (because one rope holds only one person) and they are not useful for reaching the uppermost canopy since these branches are too slender to support the ropes. Other solo techniques include tree bicycles, climbing spikes and ladders.

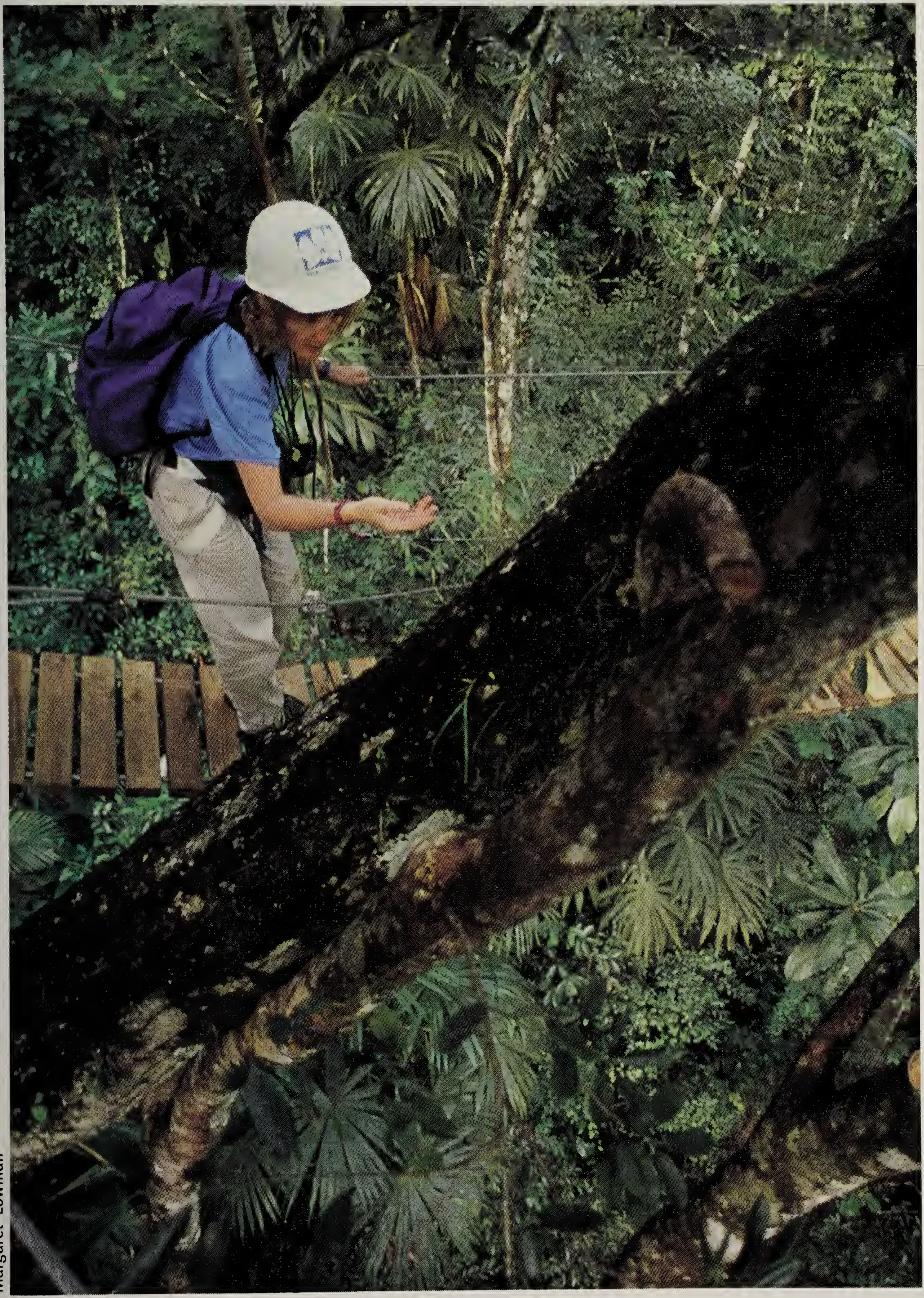
For those who do not feel comfortable dangling from ropes in mid-air, the use of more permanent canopy bases may provide a secure perch for study. Towers are stable for long-term observations but are limited in that only one or two trees are usually within reach of one tower. Platforms and bridges can be linked to form complex networks of access between many trees. The use of canopy walkways is a wonderful way to bring groups of scientists or students into the canopy together for collaboration.

Canopy walkway systems now exist in most forest types throughout the world, including Australia, North America, Ghana, Peru, Costa Rica, Western Samoa, Indonesia and Belize. The walkway system in Peru, part of the Amazon Center for Education and Environmental Research (ACEER), will be the site for the 1999 Jason Project for Education, whereby scientists will conduct field research on epiphytes (air plants) and canopy ecology in view of hundreds of thousands of students on three continents via live satellite linkage.

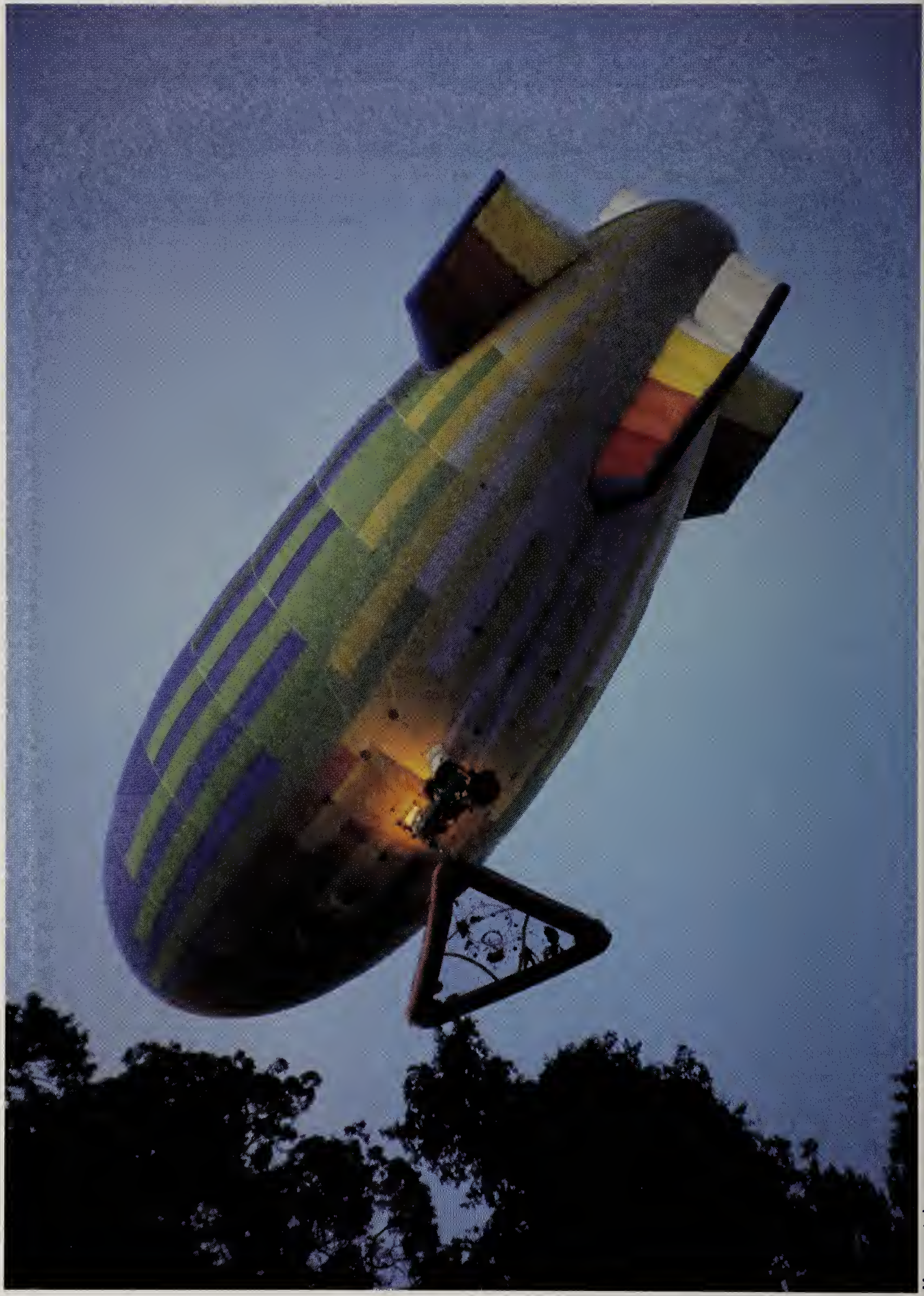
Of a more colorful and innovative nature, the Radeau des Cimes (or canopy raft) has been designed and used successfully by a French scientific team under the direction of Professor Francis Hallé of Institut de Botanique in France. Its inflatable raft is 27 meters in diameter and forms a platform on top of the forest canopy that is utilized as a base for research on the trees around its perimeter. A dirigible (or hot air balloon) moves the raft to new positions throughout the jungle, where research can be conducted on the atmosphere just above the canopy.

During 1991 and 1996, I was fortunate to participate as a canopy biologist on Radeau des Cimes expeditions to Cameroon, Africa and French Guyana, South America. In both sites, we pioneered a new canopy technique called the sled. This small 16 x 16-foot triangular mini-raft was towed across the canopy by the dirigible, similar to a boat with a trawling apparatus on the sea. It facilitated collection of canopy leaves, flowers, vines and epiphytes, as well as their pollinators and herbivores. A *National Geographic* television special called "Heroes of the High Frontier," highlights our use of this sled for research.

Another relatively new technique involves construction cranes that have been relocated from urban sites to the rain forest. A 40-meter crane was erected in 1991 in a Panama dry forest by researchers at Smithsonian Tropical



A canopy walkway system in a tropical rain forest in Belize.



Margaret Lowman

A canopy sled carried by a dirigible over the treetops of French Guyana.

Research Institute. Since then, five other cranes have been either operable or in progress, including sites in the coniferous forests of Washington state, a tropical rain forest in Venezuela, a wet tropical forest in Panama, a rain forest in Malaysia, and a tropical rain forest in Australia. Cranes are quite expensive to install (up to $1 million) but they offer unparalleled access to the uppermost canopy as well as to any section of the understory that is within reach of the crane arm.

Once the logistics of canopy access are solved, a bigger challenge lies ahead: collecting meaningful information about this complex world of the treetops. Canopy studies range from measuring sessile organisms (orchids, trees, sedentary insects) to mobile organisms (flying insects, birds, mammals) to canopy processes (studies of the interactions of organisms). All of these different topics require sampling designs that are effective at heights, can be operated in an air medium, and can be safely employed while dangling from a rope or some otherwise precarious position.

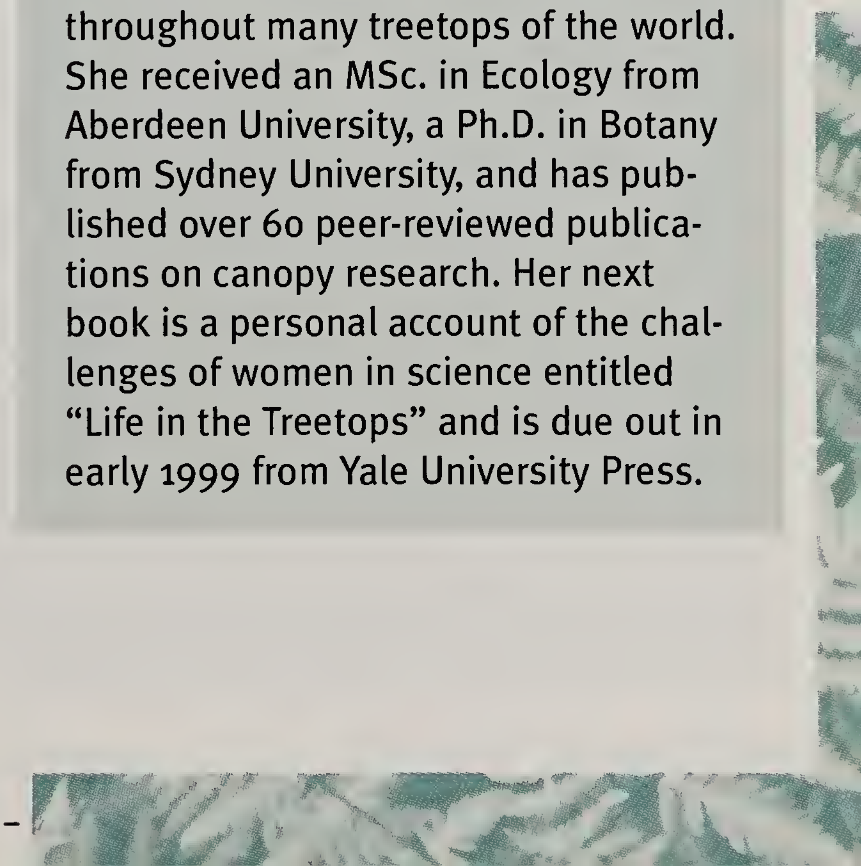
Many questions remain unanswered:

1.) How many species are there in the tropical rain forest, especially the canopy?
2.) How many epiphytes, or air plants, live within the branches of one canopy tree?
3.)How do pollinators find their host plants in this complex array of green leaves?
4.) How can we effectively implement conservation practices to maintain tracts of rain forest for future generations?

The pressures of human population give an added incentive for scientists to undertake studies in tropical forest canopies. The next ten years will be critical, as scientists attempt to understand the ecology of the canopy before much of our rain forests are cleared or fragmented. Hopefully, canopy research will illuminate more ideas about how rain forests function and will contribute to our conservation of these important forests.

AUTHOR BIOGRAPHY

Meg Lowman is Director of Research and Conservation for Selby Botanical Gardens in Sarasota, Florida and holds the "The Jessie B. Cox Chair in Tropical Botany." She has pioneered many aspects of canopy research and specializes in plant-insect interactions throughout many treetops of the world. She received an MSc. in Ecology from Aberdeen University, a Ph.D. in Botany from Sydney University, and has published over 60 peer-reviewed publications on canopy research. Her next book is a personal account of the challenges of women in science entitled "Life in the Treetops" and is due out in early 1999 from Yale University Press.



TROPICAL FORESTS: PROFOUND PROBLEM, FINE OPPORTUNITY

Campbell Plowden courtesy of Greenpeace

Logging in a Brazilian rain forest.

By Norman Myers, Oxford Fellow

Tropical rain forests are the most exuberant expression of nature to grace the face of the planet since the first flickering of life almost four billion years ago. Yet within the lifetimes of many readers of this publication, we may witness the virtual demise of these forests and their inhabitants, which include greater numbers of species than exist throughout the rest of the planet.

That's the bad news. The better news is that there is still much that can be done to slow this destruction. We have lost half of our forests already, but, we can save many of the remaining forests, provided that we expand our conservation efforts.

Deforestation Rates

First, how fast are the forests disappearing? Much depends on what we mean by "disappearing." Some bodies, notably the Food and Agriculture Organization (FAO) which is the United Nations agency responsible for forests, take it to mean the total removal of forest with not a tree remaining, and the area given over to rice paddies or human settlements such as towns. If commercial logging removes one-third of all trees for their timber, and if the operation is so heavy-handed (often the case) that most of the remaining trees are injured beyond recovery, that still leaves a "forest," albeit a travesty of the original one that had a full panoply of species and all ecological functions intact. Or if the natural forest is replaced with a plantation of eucalyptus or rubber trees, that is still, according to FAO, a forest.

Other observers, this writer and many scientists included, believe "deforestation" covers not only outright destruction but grand scale degradation in the wake of logging or intensive slash-and-burn cultivation. Therein lie the different assessments of deforestation. FAO postulates that of the 7.5 million square kilometers (3 million square miles) remaining, i.e. an expanse equivalent to the "lower 48" of the United States, less than one percent is being eliminated each year. The others assert the rate is at least two percent and likely more. Just a two percent rate means that if we continue as we are, the remaining forests will be lost within 35 years.

However, the annual rate is increasing. In the 1970s, deforestation in its broad sense accounted for one percent of forest per year, but in the 1980s it increased to almost two percent, and in the 1990s it has surely accelerated to well above two percent and could well rise to around three percent within another decade or less.

Biodiversity & Biodepletion

Tropical forests are extraordinarily rich in species. They contain at least half and possibly three-quarters of all species on Earth. In Central America or Borneo, an area equivalent to a dozen football fields can house as many plant species as the United States and Canada combined.

How many species are eliminated by a deforestation rate of two percent per year? It is difficult to determine since some species enjoy quite large ranges, and forest destruction in one locality may leave undisturbed habitat in another locality. Many scientists have wrestled with this key question. Many go along with the calculations of Professor Ed Wilson of Harvard University, who, using complex analytic models, concludes that just a one percent deforestation rate must be eliminating somewhere around 27,000 species per year, or 73 per day. This is a rough and ready estimate, but also a cautious and conservative one; it includes plants, mammals, birds and insects. It also depends on an estimated total of 10 million species worldwide, so it translates into an extinction rate of 0.27 percent per year.

That may not sound like very many, but remember that the deforestation rate is twice as high as the one percent used for the arithmetic. I personally would hazard a guesstimate, since we do not know enough about the basic numbers, that we are losing 50,000 species in the forests each year. Moreover, the rate is increasing swiftly.

Kirk Johnson

A study plot in a dense rain forest in the Cape Tribulation region of northeastern Australia. The thick vine is Entada phaseoloides *(Fabaceae), the palm vine is* Calamus *sp. (rattan), the tree numbered J3 is* Doryphora aromatica *(Monimiaceae).*

Skeptics may respond, "If we lost 73 species yesterday and the sun still came up on time this morning, does it really matter?" Yes, it does. For one thing, such a large die-off represents the opening phase of a larger mass extinction than any since the demise of the dinosaurs and associated species 65 million years ago. Do we really want to go down in history as the perpetrators of such a slaughter? We are the only species that has ever had the capacity to push a single other species over the brink into extinction, and we are the only species that has ever had the capacity to bring a single other species back from the brink of extinction. For another thing, when we eliminate a species, it is gone forever and that will often be bad for humankind in terms of our material welfare. I shall not delve further into this aspect since other chapters cover the tropical forests' contributions in terms of food and medicine.

I must, however, mention the role of the most numerous species in tropical forests — insects. Those readers who may ask what creepy-crawlies have ever done for us should consider the oil-palm plantations of Malaysia. Until the early 1980's the pollination of millions of oil-palm trees was done by human hand, an inefficient and expensive way of performing the task. The plantation owners asked themselves how the oil palm got itself pollinated in its native habitats of West Africa's forests. Researchers went off to Cameroon, where they found the job was undertaken by a tiny weevil.

Start-up stocks of the weevil were taken back to Malaysia, where they were released into the plantations. (There was no problem of ecological complications with other species since the weevil confined its attentions to the oil palm.) The pollination is now entirely accomplished by the weevil, with savings that amounted to $150 million per year in the early 1980s. We can reflect on that the next time we utilize cosmetics or other products that may contain palm oil, and the next time we hear of insect species becoming extinct in tropical forests.

Campbell Plowden courtesy of Greenpeace

A future plantation site in an African rain forest on the Ivory Coast.

Zindler courtesy of Greenpeace

The dramatic and tragic burning of a rain forest in the Brazilian Amazon.

What Else are We Losing Through Deforestation?

Consider too the environmental services supplied by tropical forests, which may be even more bountiful and valuable than material goods. The forests protect soils, helping them to retain their moisture and to store and recycle nutrients. They serve as buffers against the spread of pests and diseases. By preserving watershed functions, they regulate water flows in terms of both quantity and quality, thereby helping to prevent flood-and-drought regimes in many downstream territories.

Let us elaborate on just one of these examples, watershed services. Deforestation of upland catchments can lead to disruption of hydrological systems, causing year-round water flows in downstream areas to give way to flood-and-drought regimes. In the Ganges Valley with its 500 million small-scale farmers in India and Bangladesh, the annual costs of watershed deforestation in India alone were estimated as far back as the early 1980s at more than $1 billion. The on-site soil conservation benefits of tree cover within India's forests are worth between $5 billion and $12 billion per year, while the nation-wide value of forest services in regulating river flows and containing floods are roughly assessed at over $70 billion a year.

Some 40 percent of tropical farmers depend upon regular flows of rivers and streams from healthy watersheds to irrigate their croplands. In Rwanda, the montane forest of the Volcanoes Park (home to one of the last populations of the mountain gorilla) covers only one percent of the country, but acts as the sponge that absorbs and meters out about ten percent of agricultural water for that severely overpopulated nation. In Java, deforestation-derived siltation of reservoirs, irrigation systems and harbors produced damages valued at $58 million in 1987.

Climatic Linkages

Tropical forests moderate climate at local and regional levels through regulation of rainfall regimes. At a global level they help to reduce global warming by virtue of the carbon stocks in their plants (especially trees) and soils. This second function is vitally important to us all.

The forests contain 400 gigatons (billion tons) of carbon out of 2000 gigatons in all terrestrial plants and soils, by contrast with 750 gigatons in the atmosphere. When the forests are burned, as is the case with cattle ranching and small-scale agriculture in the forests, they release their carbon. Of the 7.5 gigatons of carbon dioxide emitted per year into the global atmosphere, and contributing half of greenhouse-effect processes, roughly 1.6 gigatons come from the burning of tropical forests.

Economists value global warming damage at $20 for every ton of carbon released. If we apply this figure to tropical forests, we find that converting open forests to agriculture or pasture would result in damage of between $600 and $4000 per hectare. This means that the "carbon sink" attribute offers a far higher rate of return than any other form of land use in tropical forests. Alternatively reckoned, the replacement of the carbon storage function of tropical forests could cost up to $3.7 trillion.

What We Can Do?

To repeat the bottom-line message: there is still much that can be done to conserve the tropical forests. True, we've already lost half of the forests, and no matter what we do we are going to lose a good deal more. We can't halt the deforestation forces overnight.

Fortunately, people are doing a lot more than was being done ten years ago. Most important of all is that a lengthy list of political leaders, in countries from the Philippines and India to Madagascar and Costa Rica, are proclaiming that deforestation is an international crisis.

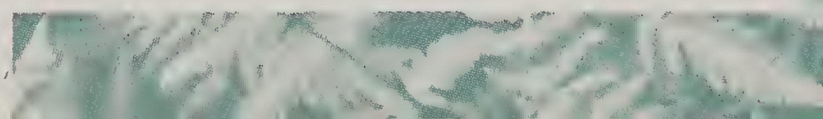
In countries outside the tropics too, the message is going out that the forests are facing terminal threat. At the 1996 meeting of the eight leading industrialized countries such as the United States, Germany and Japan, the communiqué cited problems such as inflation, unemployment, terrorism and tropical deforestation. Around the world, the issue is rising high on political agendas. Similarly, the World Bank has shifted its stance from production forestry, i.e. turning trees into two-by-fours, to protection forestry, i.e. looking out for the full panoply of the forests' contributions to us, whether watershed functions, gene pools or carbon sinks.

Two recent initiatives, the "Intergovernmental Panel on Forests" and the "World Commission on Forests and Sustainable Development, " have focused primarily on tropical forests. As for the forests' biodiversity, I calculate that 14 tropical forest areas are the sole habitats for one-seventh of all the earth's species in 0.2 percent of earth's land surface. If we could protect these "hotspots," we could go a long way to slowing the mass extinction problem.

In response, foundations and conservation bodies have poured $200 million into these key localities. Most of the funds have come from America, Britain and other affluent members of the world community, which is as it should be, when a prime part of the world's natural heritage is at stake.

AUTHOR BIOGRAPHY

Norman Myers is an independent scientist and a Fellow of Oxford University, England. He has been getting his boots muddy in tropical forests since the mid-1970s, when he traveled to Borneo and felt his ecologist's life was just beginning.



CHAPTER TWO

TROPICAL FOREST PLANT RESOURCES

Tom Lemieux

A tugboat on the Amazon River in Peru pushes a barge stacked with rain forest timber to a nearby processing station.

Few of us truly appreciate the kinds and numbers of products that come to us from the tropical plant world. The palm family alone contains over 200 genera and three thousand or more species. Most people are aware of only coconuts (*Cocos nucifera*) and dates (*Phoenix dactylifera*) as food sources derived from this family. Yet almost all palm fruits are edible and nutritious, and they are used locally by various peoples from their countries of origin.

Let's look at just one species of palm, the vegetable ivory palm (*Phytelephas aequatorialis*). The most popular use of this species' fruits, the tagua nuts, are as an ivory-like substi-

NATURAL RESOURCE PLANTS FROM TROPICAL FORESTS

By Tom Lemieux

The clove plant, Syzygium aromaticum, *in flower.*

tute in the manufacture of buttons and carvings. Local people, however, have a multitude of uses for *P. aequatorialis,* including using the dried leaves as roof thatch or for brooms. The growing tip (hearts of palm) and immature endosperm (similar to coconut milk) are consumed. The inner fruit pulp (mesocarp) is used as a bait in fish and animal traps, roots for birth control and trunks of the male plant for firewood. The male flowers are used as cattle fodder, as is the residual powder from button processing after mixing with supplemental protein. The same powder is also marketed as an industrial abrasive.

Examples of multiple uses such as this abound in the tropics and products derived from tropical plants cover a wide array of categories. Latex producing plants such as rubber and rubber substitutes; resins, gums and related exudates such as Miocene amber, currently fashionable in jewelry, as well as the famed guar gum from India, are of tropical origin. Also from the tropics are spices and flavorings such as hot peppers, vanilla, cinnamon, clove and nutmeg as well as essential oils including patchouli. Fibers and weaving materials, natural chemicals including naturally derived pesticides; fumatories and masticatories (plants smoked and chewed for pleasure), such as betel nut and coca, originate in these areas.

Worldwide, the humid tropics contain nearly one billion hectares (~2.5 billion acres) of luxuriant forests. Tropical hardwoods and timber products, perhaps more than any other rain forest products, are intricately intertwined with politics, developing countries' rights, and of course, greed. Two commonplace examples of these forest giants include balsa (*Ochroma lagopus*), native to tropical America, and mahogany (*Swietenia mahagoni*), native to Central America and the Caribbean.

Balsa has an unusually lightweight and porous wood, and has been used not only in model airplanes, but also for rafts, life preservers, insulation and furniture. The wood is strong, yet soft and easily marked and is twice as buoyant as cork. It floats readily on water with little bulk beneath the surface. Ecologically, balsa is a light gap species, germinating and growing quickly in the gaps produced on the tropical forest floor from toppled trees.

The exploited mahogany has been a prized wood for cabinet making because of its rich, dark red color, beautiful grain and polishing characteristics. It is the most important export timber of tropical America and has also been used for ship building and veneers. The list of tropical hardwood species with special or general uses is too long to cover here, but woodworkers are familiar with such names as cocobolo, rosewood, purple heart, teak, bubinga and padauk.

Although the bamboos constitute a whole tribe (Bambuseae) within the grass family, they should not be overlooked with regard to their timber-like properties. Many of the species are found in tropical Asia and tropical America where they can attain heights of up to 120 feet, especially in the Asian monsoon forests. The timber is used for building houses, bridges, scaffolding of skyscraper proportions, and stems are split for planking and thatching material. Stems of the larger species are cut to make various vessels or buckets for containing liquids. Bamboo has been used in paper making, furniture, walking sticks, weaving and wickerwork, boat masts and in many other ways.

In the category of vegetable oils, fats and waxes, again there are myriad products. Fully one-third of the plant-derived oils are used for industrial purposes. Perhaps one of the more important plants in this group has been the carnauba wax palm (*Copernicia prunifera*), native to and cultivated in northeastern Brazil. Waxes differ from oils in their chemistry and most waxes are solid rather than liquid at room temperature. The carnauba wax develops in thick secretions on the leaves which is thought to be a response to seasonal drought and hot winds. Most of the crude wax from this palm is shipped to the U.S. where it is prized for polishing and floor coatings. It is also used in cosmetics, plastics, candles and wherever a very hard, high-melting wax is desired.

Within the same category, a major vegetable oil source has been the African oil palm (*Elaeis guineensis*), derived from the fleshy fruit pulp and the seed. Soaps, candles, cosmetics, margarine, lubricants and a specialized use in tin-plating are included in the many uses of this palm.

In perfumes, there are also many sources of essential oils and floral oils derived from tropical plants. A popular and well-known fragrance is that of Chanel No. 5. The essence for this perfume is derived from *Cananga odorata* (ylang-ylang), a tree from tropical Asia that is presently cultivated extensively in the Philippines.

Of the many stories and historical

The Americas were discovered during the search for black pepper, Piper nigrum.

accounts of tropical plant products, one of the most interesting is that of black pepper as recounted by Henry Hobhouse in his book, *Seeds of Change*. Black pepper (*Piper nigrum*) was only one of many spices traded during the Middle Ages. It was, however, the spice of preference since it accounted for more than half of all spice imports into Italy for over a century, and commanded a price greater than ten times that of any other spice at the time. When crops failed, or when rodents ravaged grain supplies, or for men at sea, only salt-preserved meat prevented starvation. Pepper was the spice of choice to make heavily salted meat palatable. In the latter half of the 15th century, the Turks began to obstruct overland routes from the Middle East to India, and this resulted in an exodus of Spanish, Italian and Portuguese explorers to reach the Orient. Hobhouse writes "The Americas were discovered as a by-product in the search for (black) pepper."

Many such accounts of plants, including those that are lesser known, are tucked away in history books, anthropology texts, journals such as *Economic Botany* and even popular novels. Uncovering some of the fantastic accounts of plant products may be as simple as a trip to the library. At the very least, all of us should try to be more aware of the products we derive from rain forest habitats and we should strive to broaden our understanding of the indispensable role that such plants play for rain forest dwellers and the ecosystems which they inhabit.

AUTHOR BIOGRAPHY

Tom Lemieux is a senior instructor and greenhouse manager for the EPO Biology Department at the University of Colorado in Boulder.

John Brett

Xun carries his harvest back to the village.

Xun, Maruch and their three children walk slowly home up the long, steep hill after their day of working in the fields. Each, even seven-year-old Maria, carries a net bag on their back, hanging from a tumpline around their forehead. Each bag contains fruit gathered from long-abandoned fields and an abandoned small plot of land where Xun's grandfather lived until his death 20 years ago. Xun sweats under his 80-pound load of firm-fleshed, square-sided manzana lo'bal ("apple banana"), a family favorite. Maruch carries a couple dozen thin-skinned, tough, bitterly-sour oranges which have a piercing orange taste unlike anything found in a modern supermarket. The bag carried by 17-year-old Mario is filled to capacity with the small-fruited mangos that grow best in this Tzeltzal community in highland Chiapas, Mexico. The rich odor of the nearly-ripe fruits mingles with that of the guavas carried by Mario's sister, 15-year-old Lucia. Little Maria plods along quietly with her load of two ripening pineapples.

Were they a Zapotec or a Chol Mayan family living in the hot tropical lowlands of Chiapas, they might be walking home with tart, thick-skinned pummelos ("shaddock"), buttery cherimoyas, bright orange-fleshed papayas, tangy tamarind pods, huge starchy plantains, or single-bite, red-skinned finger bananas. On a Saturday they would be headed for the large weekend market in the central plaza where they would encounter

John Brett

Children are often critical to a family's farming and harvesting efforts.

By John Brett, Ph.D.

*The cherimoya (*Annona cherimola*) fruit tastes like a cross between a very ripe banana and a mango.*

other sellers with loose curls of cinnamon bark, pungent ginger root, small mounds of dried berry-like allspice, or on occasion, large, football-shaped pods of cacao, unroasted coffee beans.

Although they have always known these delightful fruit treats and spices, they are available to these Chiapas families because of the human propensity through time to identify the most edible plants in their environment and to take favorites on their travels, trade and conquest. Most of these fruits are not native to this region and only allspice, guava, pineapple or cacao might have been found in the area prior to the tremendous worldwide exchange of plants during the European age of expansion and conquest beginning in the 15th century; what historian Alfred Crosby calls "The Columbian Exchange." Each of these plants has a tale of travel to tell before having arrived in these remote Mexican communities.

Bananas began their travels in tropical Southeast Asia and further south in the Pacific Islands but are now naturalized in all tropical regions of the world. Though we wouldn't know it from a trip to the grocery store, there are dozens of varieties of bananas worldwide, all derived from two species of wild banana: *Musa acuminata* and *M. balbisiana*. We generally think of bananas as a sweet, soft fruit, however, in many societies they are cooked while still firm and starchy. In highland Mayan communities where corn and beans are the dietary staples, bananas are eaten as fruit, but in many lowland regions, they, along with related plantains, provide as much as 70% of daily calories when boiled, roasted or made into beer.

The genus *Citrus* includes Maruch's sour oranges (*Citrus aurantium*), the pummelo or shaddock (*C. maxima*) and its probable derivative, *C.* x *paradisi*, our familiar grapefruit. These citrus fruits were probably first domesticated in northeast India and central China and can now be found planted in dooryard gardens throughout the Mediterranean, tropical and subtropical regions of the world. They were brought to the Americas by Spanish and Portuguese colonists who themselves thought of them as native, so long had citrus fruit been grown in their native Mediterranean region.

Mario's mango (*Mangifera indica*), as its specific name indicates, also arose in India, where it has been

John Brett

Manzana lo' bal, or apple banana, is a firm-fleshed square banana local to Chiapas.

grown for over 4000 years. It made its way to the Americas via Malaysia, East Africa, around the horn to West Africa and then to the Americas, probably arriving in Brazil early in the 19th century. Mangos in their native India are consumed in every imaginable way from chutney made with unripe mangos to sweet, succulent desserts. In Mario's native Mexico they are eaten ripe as a fruit, made into juice or peeled while still slightly green, cut into spears and dusted with hot chilies.

Little Maria's pineapples (*Ananas comosus*) represent the only commercially valuable member of the large bromeliad family. Domesticated in tropical South America, it had spread throughout the American tropics before European explorers and colonists arrived at the end of the 15th century. When the fruits are fully ripe, Xun will cut off the pineapple tops then cut off the skin in four neat pieces. He will leave about one-quarter inch of pulp on the peel, and carefully set these aside. When they have finished the pineapple, Maruch will place the skin and a couple of quarts of water in a bucket, covering it well to keep out bugs and dirt. In the warm tropics, fermentation begins immediately, yielding a delightful, aromatic pineapple"beer"in about a day and a half. This slightly alcoholic brew has the consistency of pineapple juice with the fizz of soda pop.

Tropical regions of the world have yielded a wealth of fruits, most of which are unknown in temperate regions. Visit the redesigned Conservatory at Denver Botanic Gardens to see some of these. Also, check the"rare fruits"section of your grocery store or shop at "ethnic markets,"where many of these fruits are likely to be found.

LOOK FOR THESE TROPICAL FRUITS IN THE CONSERVATORY:

Common name	Scientific name	Uses	Native lands
Allspice	*Pimenta dioica*	Spice	Cent. Amer./West Indies
Banana, plantain	*Musa* spp.	Fruit, staple food	SE Asia, Pacific Islands
Cacao	*Theobroma cacao*	Beverage, confection	Tropical America
Caimito, Star apple	*Chrysophyllum cainito*	Fruit	Tropical America, West Indies
Cherimoya, custard apple	*Annona cherimola*	Fruit	Tropical America
Cinnamon	*Cinnamomum zeylanicum*	Spice	E to SE Asia
Coffee	*Coffea arabica*	Beverage	NE Africa
Guava	*Psidium guajava*	Fruit, juice	Tropical America
Mango	*Mangifera indica*	Fruit, juice	India/China
Miraculous fruit	*Synsepalum dulcificum*	Fruit	Tropical Africa
Papaya	*Carica papaya*	Fruit, juice	Tropical America
Pineapple	*Ananas comosus*	Fruit, juice	Tropical America
Pummelo, shaddock	*Citrus maxima*	Fruit	Southeast Asia
Tamarind	*Tamarindus indica*	Juice, spice, jelly	India

John Brett

Pineapple, Ananas comosus.

AUTHOR BIOGRAPHY

John Brett is Assistant Professor Adjunct in the Department of Anthropology at the University of Colorado at Denver. He worked at Denver Botanic Gardens for six years as the Community Gardens Coordinator before attending graduate school and receiving his Ph.D. from the University of California at Berkeley and U.C. San Francisco. He has conducted ethnobotanical research in Chiapas, Peru and Bolivia for the last ten years.

We have only begun to understand the biological diversity of our tropical forests, and studies indicate that they are a more valuable resource in their natural state than when transformed into pasture or cut for lumber. Botanically-derived medicinal products, however, are one commodity that, when correctly monitored, can potentially release native peoples from poverty while sustaining biological and cultural diversity. Currently, botanically-derived pharmaceutical drugs dominate the market and herbal products are expanding at 20% annually. Clearly, the discovery and harvesting of these products can be a model for tropical forest preservation.

Methods to identify medicinal plants from tropical areas include: random screening, taxonomic collecting (or sampling by botanical family) and ethnobotanical study. Interestingly, it has been shown that ethnobotanical discovery methods are most successful and, therefore, demonstrate greater potential in the responsible development of medicines.

Ethnobotany

Ethnobotany is a multidisciplinary science based on the interaction between plants and people, and is not limited to plants used for maintaining health. It also includes plants used for food, clothing, religious ceremonies, ornamentation or for shelter. In the past, ethnobotanical research was predominately a survey of the plants used by the villagers. A trained botanist identified the plants and recorded their uses. Sometimes there was an

Trish Flaster

Doctors interviewing a tribal healer to help identify plants used to treat specific diseases.

By Trish Flaster

anthropologist present to translate the cultural disease categories, but there was typically no physician present to identify the disease. Reciprocity was minimal and rarely were any environmental or cultural concerns included in the research process.

Today we initiate projects that have the potential to lower the poverty levels of these people, allowing them to make more educated decisions about their future directions. These new approaches enhance the quality of the science, provide compensation for the cultural groups and take into account environmental concerns. This modern approach is based on an interdisciplinary team usually composed of an ethnobotanist, an anthropologist, an ecologist and a physician. These team members may be in-country colleagues who have arranged the expeditions and the contractual agreements for return of benefits to the host community.

How the ethnobotanical information is gathered is often a pre-planned technique of the anthropologist or ethnobotanist. The technique depends on whether there is a focus on a particular disease category or a general survey, and if there is time for just an interview or participation in the process for several months. The key is to elicit objective answers to your questions and to be sure that the diseases being described are clearly understood by both parties.

Using signs and symptoms to describe the disease allows for an equal exchange of information. Titles and names can be misleading and unknown. Some native people are often eager to be helpful and may respond positively even if the answer is incorrect. Visual aids are helpful.

The interview may take place in the field, in the healer's home or in a community meeting place. Depending on the culture, one healer or several may want to offer a response. Often because your presence is novel, everyone wants to participate. Usually, the true healers will stand out from the general population.

As the healers identify the plants they use to treat specific diseases, data is recorded, the plants are collected and voucher specimens (or plant reference collections) and active plant part samples are taken. Not all expe-

Trish Flaster

Voucher specimens, or plant reference collections, are taken for all potential medicinal plant sources.

ditions collect plants, but voucher specimens are always taken to correspond with the interview so accurate correlations can be made after returning to the lab. At least one of the collected vouchers is left in the country of origin, another archived at an herbarium where it is positively identified and others may be stored in researchers' labs.

The recording of detailed information during the expedition is crucial for isolating the active molecule and obtaining reliable and reproducible collections of a potential product. No detail is too small. All the data is entered into a database and a copy returned to the foreign collaborators.

After the plants have been identified to genus and (hopefully) species, extractions are tested for biological activity. The ethnobotanical data is critical in these laboratory processes. The information supplied by the natives can successfully lead to positive results while academic approaches may provide inactive compounds or no activity at all.

From here the pharmaceutical process is streamlined between chemical and biological assays to isolate the active molecule. This can take from one to nine months or more depending upon the complexity of the molecule, and the efficiency and equipment of the research team. During this time one may need to be acquiring more of the raw botanical material. This allows time to collect more data and compare shipments.

Obtaining large quantities of raw materials before the process begins

Trish Flaster

A plant population being surveyed to verify a sustainable supply.

EXAMPLES OF PLANT DERIVED DRUGS INCLUDE:

Drug Name	Scientific Name	Benefit
Aspirin	*Filipendula ulmaria*	analgesic
Atropine	*Atropa belladonna*	eye drops
Digoxin	*Digitalis purpurea*	atrial fibrillation
Tubocurarine	*Chondrodendron tomentosum*	muscle relaxant

may be a company operating procedure to remove any biological and chemical variation that could exist during the discovery process. However, if the plants are collected at a different time of year than specified by the healer, activity may only be present in small amounts, if at all.

When isolation and identification of the bioactive molecule is completed it could dictate more research to identify other plants with greater endogenous amounts of the same active compound. The plant populations may need to be surveyed to verify a sustainable supply. Unfortunately, in some cases the plant may be endangered or difficult to import from the country from which it was originally obtained. In this case, it may be necessary to cancel the project.

Many issues have caused an erosion of the tropical regions of our planet, but for many years only the biological factors associated with this loss have received investigation. Only recently have we recognized that areas of great biological diversity overlap with those of cultural diversity. Therefore, it is logical that when the environment is disturbed, the inhabitants' ecology is also compromised. Plants are nurtured and manipulated by their co-inhabitants, humans. Only when both plants and people are considered as an integral group can botanically-derived medicinal products sustain us.

AUTHOR BIOGRAPHY

Trish Flaster is a professional Ethnobotanist who specializes in botanical procurement, ethnobotanically-based product development and implementation of quality assurance programs including sustainability of biological and cultural diversity. She is currently CEO of the consulting firm, Botanical Liaisons and has also served as a researcher and botanist at Celestial Seasonings and Manager of Botanical Sourcing and Ethnobotanical fieldwork for Shaman Pharmaceuticals.

Gary Davis

The dramatic veining of a giant leaf from the Philodendron gloriosum *vine.*

By Gary Davis

When asked about tropical plants, most people often think of orchids, bromeliads, ferns, philodendrons, ficus trees and other exotic plants. These unusual, typically gorgeous plants that originate from the tropical forests of the world, are referred to as tropical ornamentals.

The newly renovated Boettcher Memorial Conservatory at Denver Botanic Gardens contains hundreds of these plants which show a wonderful diversity of color, texture, shape and size. While exploring the new exhibit, visitors will experience an environment that is very different from what is present just outside the glass building. The climate of the Conservatory is very warm, with temperatures consistently ranging from the upper 60's to the mid 80's. The humidity level ranges from 65% to 85%.

The plants include a myriad of epiphytes (plants which grow on other plants, but are not parasitic), numerous species of orchids with beautiful, often delicate-looking flowers, bromeliad species that display flamboyant floral structures, anthurium species with wonderful, textured

Orchids are one of the most recognizable and visually appealing groups of tropical, ornamental plants.

foliage, striking flower structures and brightly colored seed clusters, and jungle cactus with unusual stems and interesting flowers. Visitors can also see tall palm trees, economic plants from the tropics and many assorted tropical ornamental trees and shrubs. All are unique sights to this part of the country.

Following is a sampling of the many plants of the Conservatory:

Epiphytes

The Conservatory contains a large and diverse collection of epiphytic plants. The main display area for these plants is on a 40-foot tall replica of the remains of a banyan tree which has been felled by lightning. This tree houses orchids, such as the wonderful *Brassia verrucosa* called the "spider orchid," with many pale green flowers that have dark green or red-brown spots, and, *Cattleya* spp. with spectacular flowers that bloom in an amazing array of colors and sizes.

Jungle cactus, which are true cactus that inhabit the tropical forests, can also be seen climbing up the tree in a vine-like manner and dangling down from high branches. The mistletoe cactus (*Rhipsalis* spp.) grows on dead tree stumps or on areas of living trees where little organic debris, moss or constant moisture is available. The blooms are generally single, but are sometimes clustered, and are small

Lipstick plant, Aeschynanthus lobbianus.

with few to several sepals and petals. The fruits produced are white, pinkish or red berries. The orchid cactus (*Epiphyllum* spp.) is primarily epiphytic in its native environment. This plant has flat, two-or sometimes three-angled, round-toothed stems with flowers that are usually large and showy. Most orchid cactus bloom during the day, but some open only at night. The fruits are round to egg-shaped and contain many seeds that are red or purple.

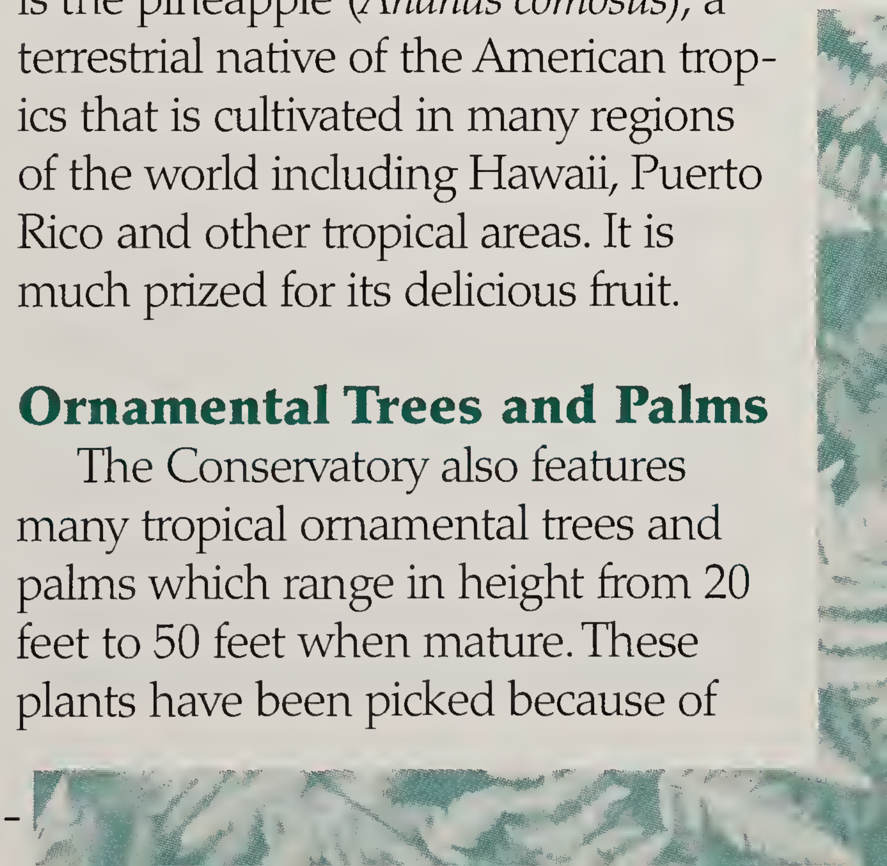
Ferns are another wonderful group of plants that include epiphytes of assorted growth habitats. Included in this group is *Davallia fejeensis* from Fiji, which has horizontal stems, called rhizomes. These rhizomes may creep just above the soil surface, grow in rock crevices, or grow across rocks and into trees. They will produce roots to serve as anchors, allowing a fern to climb, eventually covering large sections of a tree or branch. The bird's nest fern (*Asplenium nidus*) which inhabits many tropical forests and is mostly epiphytic has attractive, glossy green leaves and a formal rosette. The staghorn fern (*Platycerium* spp.), which has fronds that resemble antlers, is an epiphyte from the tropics of Asia and South America. These impressive ornamentals are usually very large and are generally grown in greenhouses or conservatories.

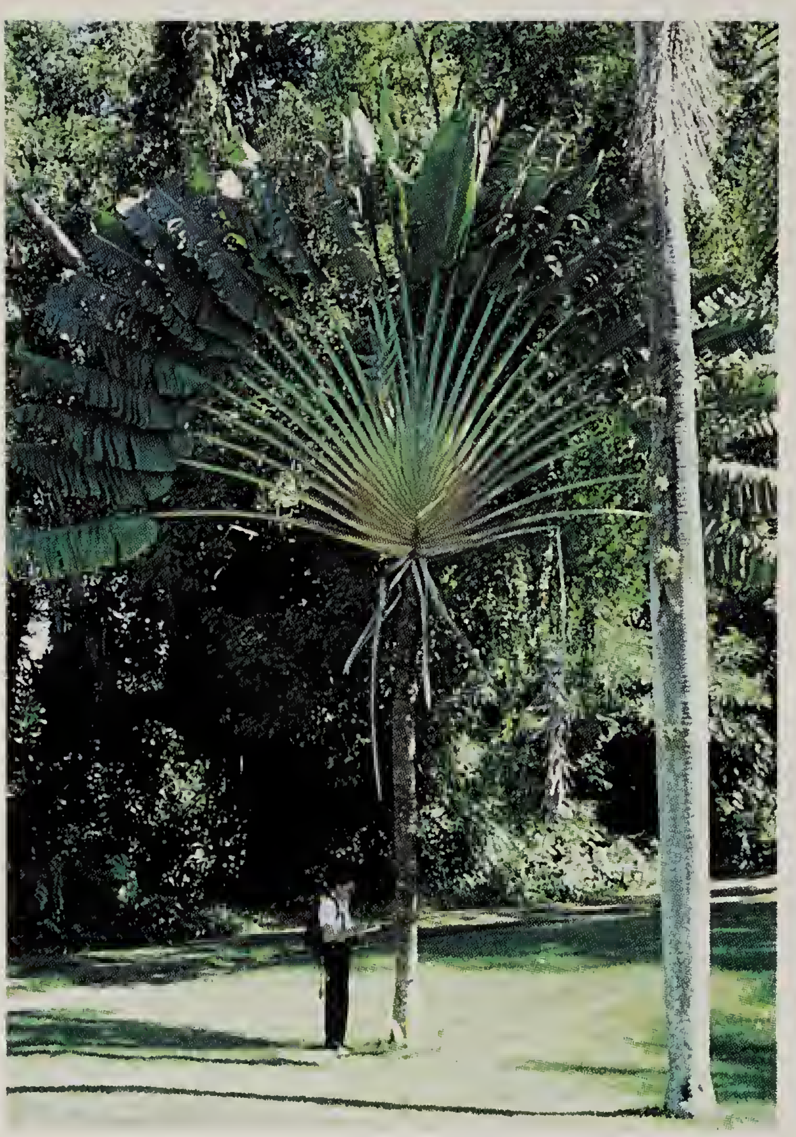
The gesneriad family also includes many showy epiphytes, including the lipstick plant (*Aeschynanthus lobbianus*) and the goldfish plant (*Nematanthus gregarius*). These grow perched on trunks or branches and have very colorful flowers. The most familiar member of this family is the African violet. *Saintpaulia* and *Sinningia* are two genera from this family which are terrestrial rather than epiphytic.

The bromeliad family includes many very attractive members whose floral structures are often quite bold and unique. Most have bracts which are strikingly colorful and give the plant a very exotic look. These modified leaves are attractants for pollinators and usually contrast the foliage and flower color. Among some of the prettier species is *Aechmea mariae-reginae*, a native of Costa Rica, where it grows as an epiphyte in tall trees. It is a large plant, three feet in diameter, with mottled green leaves that form a graceful open rosette. The eight-inch long cylindrical flower head is borne on a three-foot tall, erect spike. From this spike, four-inch long hot pink bracts hang down like ribbons. The most common member of this family is the pineapple (*Ananas comosus*), a terrestrial native of the American tropics that is cultivated in many regions of the world including Hawaii, Puerto Rico and other tropical areas. It is much prized for its delicious fruit.

Ornamental Trees and Palms

The Conservatory also features many tropical ornamental trees and palms which range in height from 20 feet to 50 feet when mature. These plants have been picked because of





Gary Davis

The thick leaf stems of the traveler's tree, Ravenala madagascariensis, *can store up to a quart or more water.*

their qualities as flowering specimens and their economic impact as natural resources. Some of the more interesting trees and palms include :

Butea monosperma, or flame of the forest, is a tree that grows to about 50 feet and at bloom time is covered with bright orange-red flowers. It is also the source of the gum "Bengal Kino." *Chrysophyllum cainito,* or the star apple, can reach up to 50 feet tall. The tree has leaves that are dark green and shiny on top and golden-brown and silky on the underside. The fruit which is round, smooth and purple and must be eaten ripe, is much prized by the peoples of tropical America. *Ravenala madagascariensis,* or traveler's tree, is an imposing member of the banana family which can attain a height of 50 feet. The long, thick, overlapping leaf stems can store a quart or more of water and have been noted to be a supply of water for a thirsty traveler.

Other highlights of the Conservatory are a collection of palm trees in a variety of shapes and sizes. Included are the thatch palm (*Coccothrinax crinata*), coconut (*Cocos nucifera*), and *Licuala grandis,* a native of tropical Asia. *Licuala grandis* has a single trunk and reaches six to nine feet tall. It is a beautiful palm with unusually shaped leaves that are mostly circular and multi-ribbed. The fruit is egg-shaped, shiny and crimson-red. This palm prefers to be grown in partial shade where there is constant moisture.

The Conservatory will also house many attractive shrubs and other herbaceous (non-woody) plants. These include banana (*Musa* spp.), lobster claw (*Heliconia* spp.), ginger (*Alpinia* spp.), Hawaiian tree fern (*Sadleria cyatheoides*), pepper (*Piper nigrum*) and many other truly exotic, ornamental plants.

AUTHOR BIOGRAPHY

Gary Davis is the Operations Supervisor for all "Horticulture under Glass" at Denver Botanic Gardens, including the greenhouses and Conservatory. Gary has worked at Denver Botanic Gardens for 25 years.

CHAPTER THREE

TROPICAL FORESTS INTERPRETED

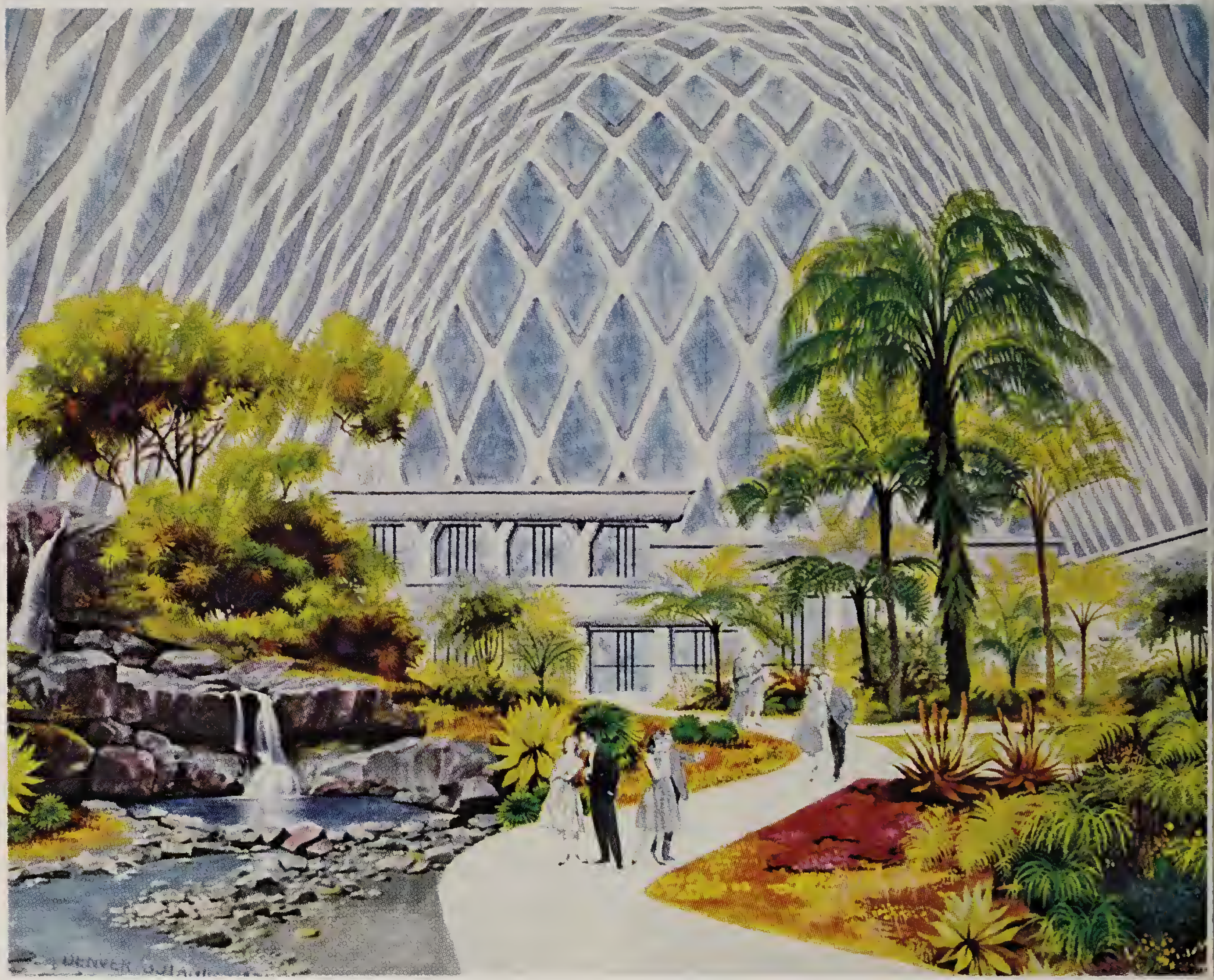
THE BOETTCHER MEMORIAL CONSERVATORY: A HISTORICAL REVIEW

By Harriett McMillan

Denver's cityscape became more interesting when the Boettcher Memorial Conservatory was dedicated on January 16, 1966. The Conservatory's unique architecture and exotic interior environment helped make Denver Botanic Gardens a main attraction in the region. Here was the only facility of its type between St. Louis and San Francisco. The architecture of Victor Hornbein and Edward D. White, Jr. received international attention and acclaim from architects and engineers.

A greenhouse structure was a necessity for Denver Botanic Gardens in order to satisfy the fundamental requirements of a botanic garden; specifically the exhibition of living plants, among them plants not native to the immediate region and those that cannot survive out-of-doors in this locality. The design team set out to build a conservatory that would be as free of maintenance as possible. They sought design techniques that would eliminate the drip of condensation from the ceiling. Entrances were planned for two levels as well as elevated observation points that would allow viewing of the indoor garden from above.

Concrete was the chosen construction material due to its maintenance-free characteristics and aesthetic potential. Consideration was also given to the fact that the Conservatory would serve as a memorial to the late Claude Boettcher, founder of the Ideal Cement Company. A stunning structure constructed of reinforced concrete was deemed a fitting tribute. Gerald H. Phipps, Inc. served as the general contractor and devised the method of



One of the original conceptual renderings of the Boettcher Memorial Conservatory.

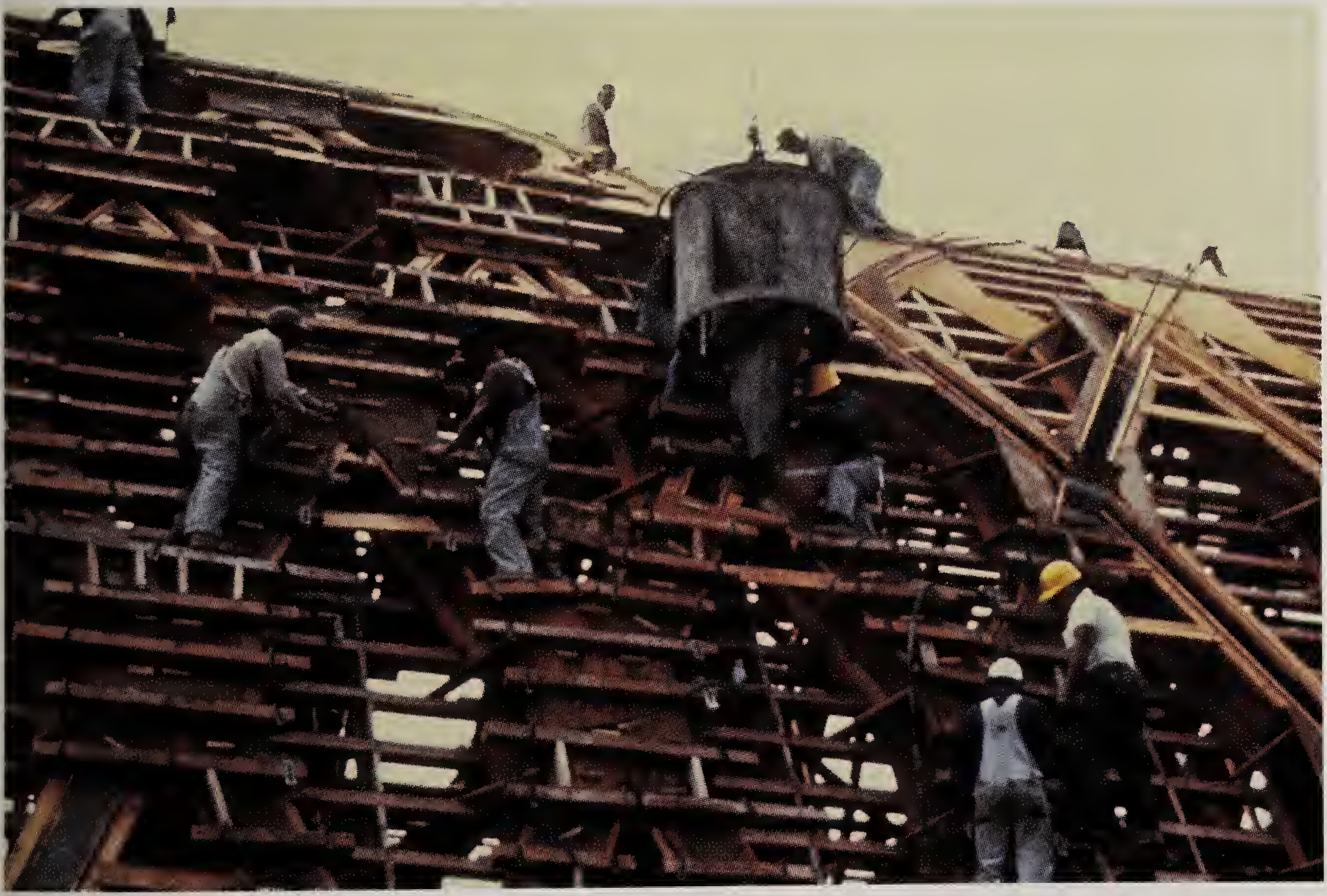
pouring the concrete in place rather than precasting sections. A wooden deck was constructed to support the wood forms for the sides and tops of the concrete structure. The wood forms were reused as the construction progressed. The concrete framework took approximately ten months to construct from the foundation to the final arch in the vault.

Installation of the Plexiglas® pyramids followed. These were specifically designed to gather condensation and lead it through "weep holes" to the outside. As the Conservatory took shape the mechanical room was enclosed and fitted with the necessary machinery to provide the controlled tropical climate. The interior topography was formed and streams, waterfalls and pools added their ambiance.

Finally, plants transformed the vaulted space into an Eden of tropical vegetation of economic and ornamental importance. Some of the plants featured unusual botanical characteristics and some illustrated steps in plant evolution. The fifty-one foot ceiling accommodated larger trees and provided room for growth. And grow they did. Within fifteen years several of the larger palms soared to the top and were removed. The rubber tree planted at the west end of the Conservatory was pruned on a regular schedule to contain its substantial growth in the allotted space.

As years passed, the collection was changed frequently to provide continuing excitement for visitors and volunteers alike. The Associates of DBG, under the auspices of the Education Department, developed a training program designed to educate knowledgeable guides for tours of the Conservatory. For thirty years the Conservatory served the community as an open window to the mystery and intrigue of the tropical world.

Once again, the Boettcher Memorial Conservatory achieves a standard for excellence at Denver Botanic Gardens. The unique tropical forest environment within the exhibit will affirm the legacy of Dr. A.C. Hildreth, Director of DBG when the original Conservatory was planned. Dr. Hildreth avowed that "Such a plant collection will contribute to the enjoyment and botanical appreciation of the general public. It will be invaluable to teachers and students of biology in our schools and colleges, many of whom might otherwise never see living tropical plants." With this new exhibit, Denver Botanic Gardens welcomes the new century with a revitalized interpretive display that acclaims its commitment to the education and enjoyment of horticulture.



In 1965, workmen pour concrete to form the distinctive domed structure of the Conservatory.

In the original planting, a lone palm will soon be joined by a forest of exotic plants. The tropics have come to Denver.

AUTHOR BIOGRAPHY

As the Horticulture Information Specialist for Denver Botanic Gardens, Harriett McMillan is responsible for educating both local and national audiences about horticulture and Denver Botanic Gardens. She has more than 20 years of experience in horticulture as a teacher, nursery sales manager and is a frequent lecturer and contributing writer to *The Denver Post* newspaper and many other publications.

THE NEW FACE OF BOETTCHER MEMORIAL CONSERVATORY

by James E. Henrich

An outside view of the Boettcher Memorial Conservatory.

Tropical forests have been intimately associated with Colorado since the Jurassic Period, as described by Dr. Kirk Johnson. Tropical forests and their diversity, ecology, economic importance in our lives and their plight continue to evoke tremendous intrigue. It is this intrigue that inspires botanical gardens to recreate tropical forests within environmentally controlled greenhouses to demonstrate their value and wonder.

Over 30 years have passed since the Boettcher Memorial Conservatory opened to the public in January of 1966. Since that time its heating, cooling and humidification systems and the vital, thin glazing, which had been state of the art, had severely deteriorated or become unreliable.

The time had come to renovate the award-winning facility. Planning for the renovation began in October, 1992 when "Requests For Qualifications" were mailed to a select list of qualified architects. An ad hoc committee chose BIOS, Inc., from Seattle, Washington, as the architect in December, 1992, and the first concept drawings were received in June, 1993.

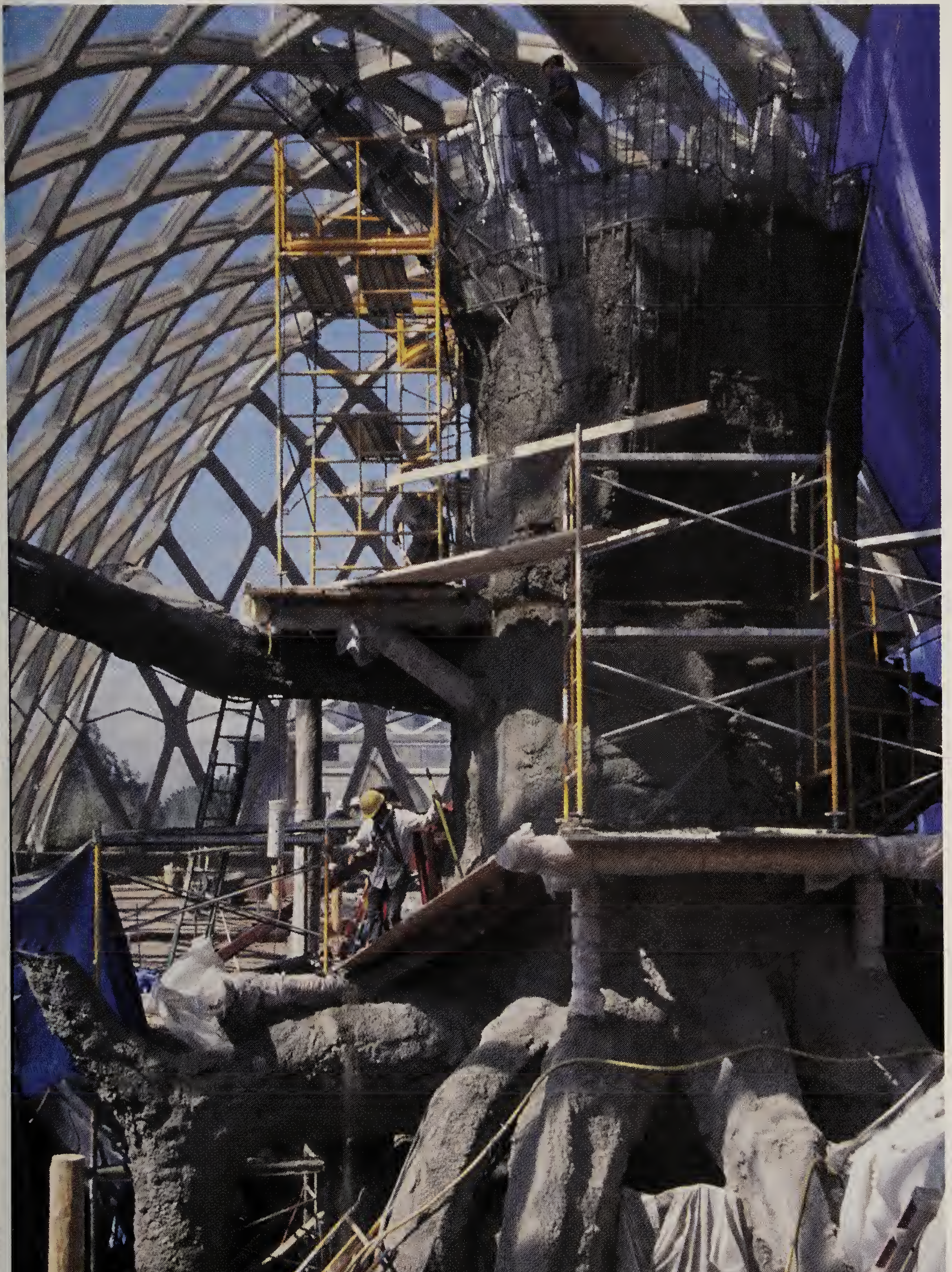
Concurrent with development of architectural drawings, staff, volunteers and outside consultants began planning the planting and interpretation themes; construction drawings were completed in December, 1997. Preparation for construction required horticulture staff to select existing plants to be saved or propagated for use in the new planting. The balance of the plants were given to the Denver Zoo, Butterfly Pavilion & Insect Center, Denver Public Schools, Henry Doorly Zoo and Grand Junction Botanical Garden. Then, in January, 1998 construction began.

The mission statement for the renovation as seen by the architect, and the Conservatory Planning Committee was: "The Boettcher Conservatory will be reconstructed to house an exhibit of tropical plantings in order to 1) communicate an aesthetic impression of the plant materials taken as a whole, 2) to provide a basis for understanding the need for stewardship of tropical ecosystems and by extension, local ecosystems, 3) to provide access to direct experience of individual specimens, 4) to provide information and interpretive material that increases the appreciation and understanding of the plant material and its ecology and 5) to provide improved physical conditions for the culture and care of plant materials, for the safety and utility of the visitor, for safe and efficient access for operations, care and maintenance, and to extend the useful life of the facility for another 25 years."

"The overall goal of the exhibit is to provide a sensory and intellectual understanding of the range and diversity of tropical plants — of their interactions with each other, and the other elements of their environment including animals, natural phenomena and evolutionary conditions. The exhibit provides an overview of the value of tropical botanical resources and their current jeopardized state in order to stimulate concern and the action of stewardship of the environment."

"The primary theme of the Conservatory is that of a believable tropical plant community, occurring between 23.5 degrees north latitude to 23.5 degrees south latitude. Two forests are represented, rain forest and dry forest. The former is composed to provide a glimpse into the multiple layers of a true rain forest (ground, understory and canopy layers). Both will contain plants of pan-tropical origins. Subthemes include ecology, human use or ethnobotany, science and politics."

Excitement now runs high as Denver Botanic Gardens unveils the newly renovated Boettcher Memorial Conservatory. The new design replaces steep gravel paths with textured concrete paths made to resemble stone featuring leaf impressions and animal foot prints. Accessibility for physically challenged visitors is accomplished via an elevator shrouded within an artificial banyan tree, the focal point of the plan. The "tree" will serve as a habitat for myriad epiphytes and lianas. Modeled after a large, sprawling banyan, the branches support two decks and permit visitors to view life in the forest canopy.



Julie Behrens

Construction workers finalize the structure of a giant banyan tree — the centerpiece of the new Conservatory plantings.

All of the mechanical systems providing life support are new. Heating is still provided by perimeter steam pipes, but the air is humidified from a fog system. All air circulation fans are new and can operate at two speeds, a great improvement over the original single-speed fans. Cooling is now accomplished with a two-step process of evaporative cooling and fog. Humidity from the air circulation system is enhanced with fog from special effect fog nozzles strategically placed throughout the space. Geologically accurate rock formations have been used throughout, providing an opportunity to exhibit epiphytes and fossils. A stream meanders through the forest to a pond near the east entrance, creating a wonderful ambiance of flowing and splashing water, a vital element in the tropical forest.

Special effect and emergency lights have been used along pathways to highlight selected plants, create a safe facility and extend the usable time of the Conservatory into the evening hours. The interior surfaces of the concrete superstructure were sealed with a plastic resin paint to ensure its integrity for years to come. Completing the renovation, a five-year plan has been implemented to replace all of the Plexiglas® glazing panels; the first installment is scheduled for late 1998.

The large banyan represents a tree whose top branches have been broken off in a lightening storm. The bro-

Tropical plants await their new home.

Denver Botanic Gardens

ken branches have fallen into an adjacent bed providing an opportunity to interpret the ecology of a light gap where decomposers break down the fallen branches into valuable nutrients so desperately needed by the plants and adventitious species that rapidly begin the reforestation process. The buttressed tree base simulates real tree characteristics common to tropical forest trees.

Interpreting the new tropical forest is vital to understanding it and plans have undergone refinement for over two years. Signs explaining tropical rain forest ecology, ethnobotany, fossils from tropical forest plants and more, are displayed throughout the exhibit. Introductory information about tropical forests sets the stage for the display before you enter the Conservatory. Large, general information signs are located throughout the Conservatory and smaller "story" or "factoid" signs are located at points of special interest.

Trained docents will deliver insights of the ecological interpretation of the tropical forest and how the plants impact our daily lives. Although thousands of miles removed from the actual tropics, visitors will gain appreciation not only for the magnificent diversity and beauty of these ecosystems, but also for their fragility and priceless value to our present and future world.

Look for interpretation about rain forest destruction in Marnie's Pavilion (located at the west end of the Conservatory) accompanied by "What you can do to preserve the rain forests!" information.

Denver Botanic Gardens now stands poised to present an exhibit that will provide Denver with one of the most exciting and compelling displays of tropical plants and ecosystems anywhere outside of the tropics.

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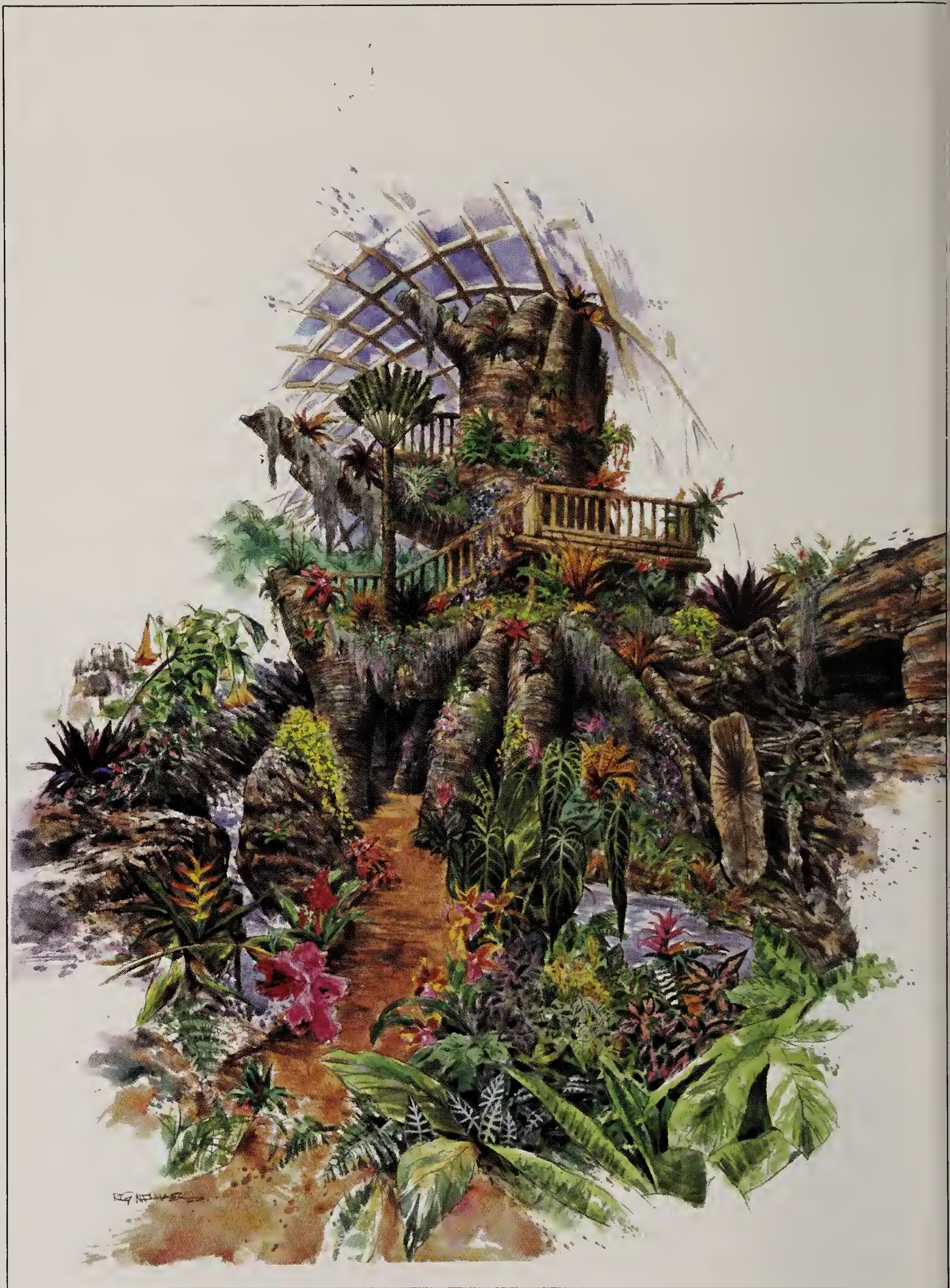
Denver Botanic Gardens staff and contractors struggle with the challenge of planting a half-ton tree.



An artist's rendering of the spectacular new exhibit.

AUTHOR BIOGRAPHY

James E. Henrich has been Director of Horticulture at Denver Botanic Gardens since 1992. He has degrees in biology, chemistry and horticulture and his experience encompasses the full spectrum of horticulture with special interest in monocots, especially iris and their relatives.

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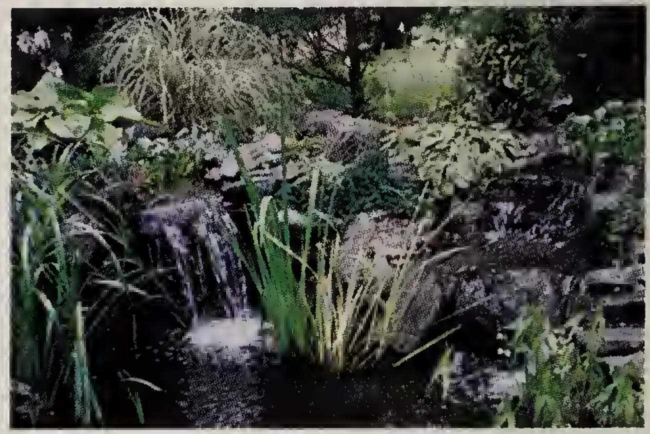

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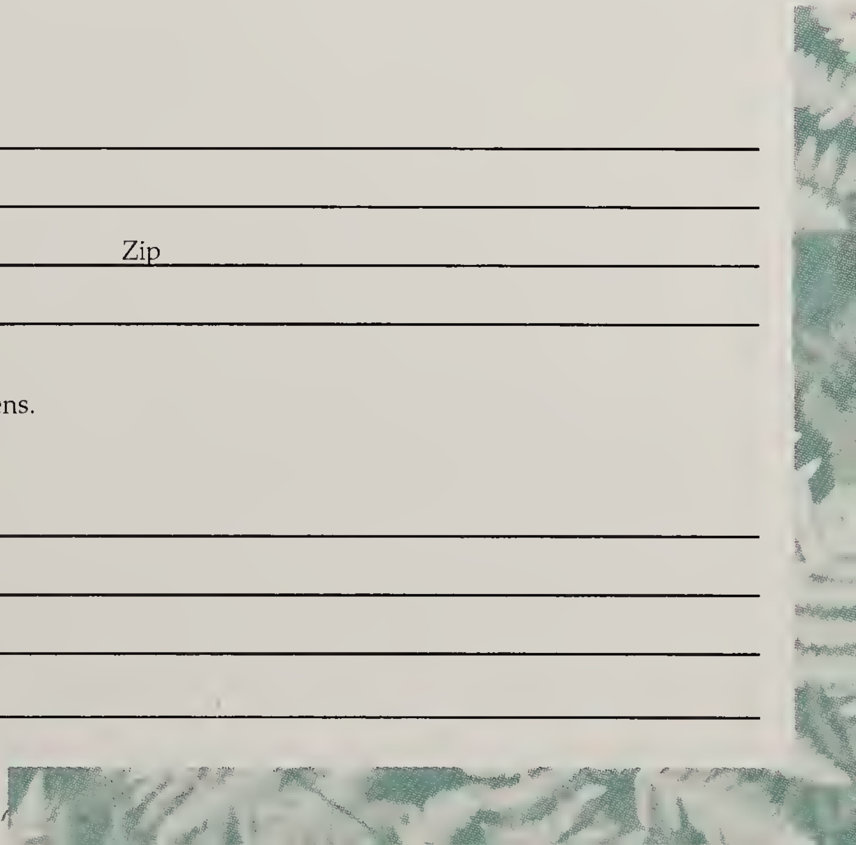

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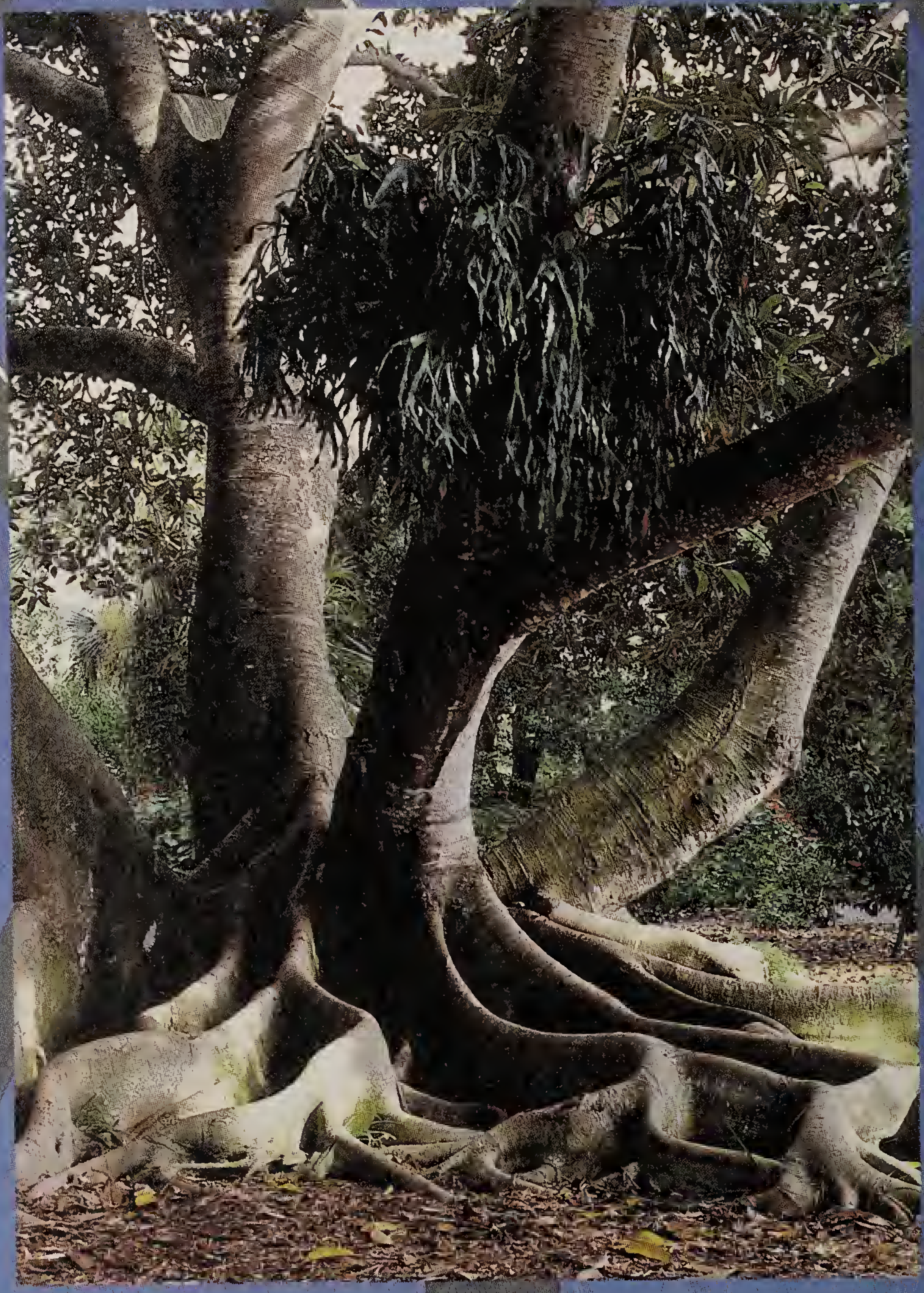

What's Bugging Your Garden?

Mountain, Plain and Garden
The Magazine of Denver Botanic Gardens
Volume 56, Number 1, Spring 1999

INTRODUCTION

Insects and other bugs are an integral part of gardening life whether we like it or not. Most are benign, many confer inestimable benefits and only a few offend our sensibilities by making a leaf or flower less than perfect. Sadly, many gardeners treat the insect world as hostile, use words like "enemy" and "pest" to describe it, and reach for the insecticide spray whenever anything with six legs or more enters their manicured world. By doing this we make the world a poorer place, depriving ourselves and our neighbors of the immense good many insects do, not least being the pleasure of butterflies which make our gardens feel so alive.

In my last garden, an acre south of Miami in Florida where insects are year-round and in vast numbers, I almost never used insecticides. For the first year I had problems. The fruit trees had scale, aphids were everywhere, mealybug armies invaded chosen plant gems and a few things died. By year two, the natural predators had moved in and everything settled into a balance in which nothing was perfect but the garden was alive. Butterflies and birds were everywhere and the cost and stress of controlling garden insects never marred the therapeutic pleasure I got from gardening.

The articles in this volume of *Mountain Plain and Garden* celebrate insects, give us an insight into the immense good they can do and look at the most environmentally friendly way we can deal with those we simply cannot tolerate. In the garden there is rarely any excuse for blanket treating an area with insecticide. There are almost always spot treatments with oils or soaps if even simpler methods such as spraying with water or picking off individual insects doesn't work.

But I would go even further and encourage you to enjoy your insects. A simple hand lens can show you unimagined beauties and reveal fascinating life cycles. So what if a leaf gets chewed? Remember it is our attitude to some insects that brands them as bad — there is, to the best of my knowledge, no documented case of an insect feeling malice towards a gardener.

Brinsley Burbidge, PhD
Executive Director, Denver Botanic Gardens

The larva of a black swallowtail butterfly climbs a parsley stem.

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Julie Behrens, Managing Editor
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Front/back cover photos: Hens and chicks (*Sempervivum* sp.), praying mantis by Whitney Cranshaw (front). Monarch by Butterfly Pavilion and Insect Center (back).
Inside covers: Lady beetle larvae and adult eating aphids by Butterfly Pavilion and Insect Center.

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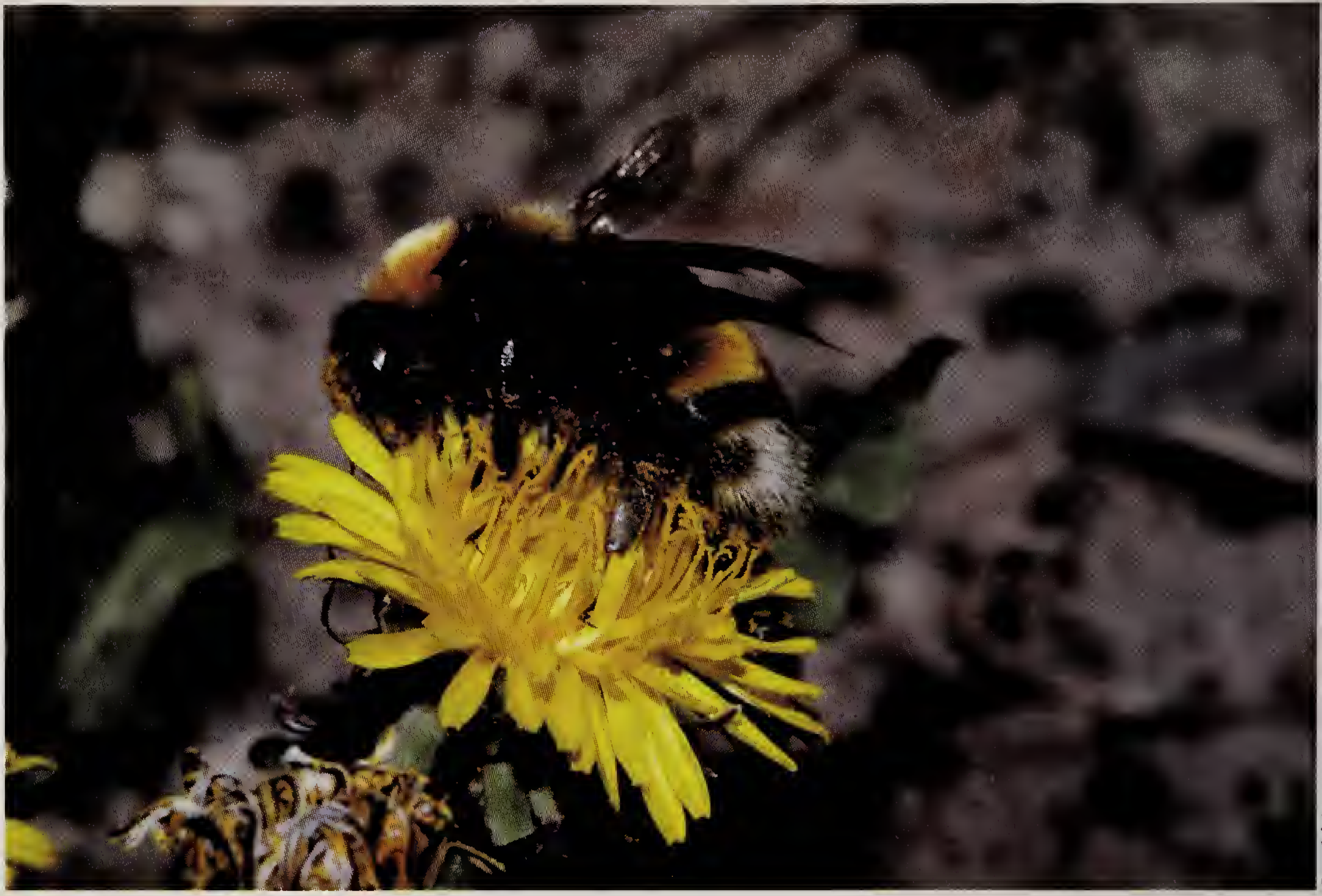


The bee is the classic insect pollinator of flowers.

"Let me tell you 'bout the birds and the bees and the flowers and the trees..."

from The Birds and the Bees *by Herbert Newman (recorded by Jewel Atkins on Eva Records).*

Do you remember when Mom and Dad sat you down to tell you about "the birds and the bees," and how they got a bit sidetracked? They likely talked about human sexuality and never did get back to the subject of birds or bees. The fascinating topic of plant sex, better known as fertilization by pollination, was probably never discussed.

Yet, pollination is critical to the world as we know it. Most plants are only able to exist because of pollination. According to Stephen Buchmann and Gary Nabhan, authors of *The Forgotten Pollinators*, approximately one-third of the food we eat is dependent on the activities of pollinators. The vast majority of the 240,000 known species of flowering plants depend upon insects to pollinate them.

Pollination is how plants "mate." Flowers contain the sex organs of plants. In most cases, the flowers include both male and female parts, although some plants have separate male and female flowers, or even separate male and female plants. The female eggs, or ovules, are usually hidden deep within the flower's ovary. Attached to the ovary is a tubular extension, called the style,

by Michael J. Weissmann, PhD

that terminates in a receptive area called the stigma. The male "sex cells" are found in the pollen produced by the flower's stamens. In order for the ovules to become seeds, pollen must be received by the flower's stigma. From the stigma, the pollen then germinates and grows a tube through the style to reach the ovary where it fertilizes the ovule. Pollination, then, is the process of getting the pollen to the stigma so that it can fertilize an ovule.

It is possible for some flowers to self-pollinate, using their own pollen to fertilize their own ovules, however, this process can have potential problems. The seeds produced in this way get all of their genetic material from one parent and thus, lack genetic diversity. Such inbreeding tends to weaken a species by creating a population with all individuals genetically similar. Diversity betters the odds during times of change, allowing at least some of the offspring to have a chance of survival.

The best way to achieve genetic diversity is to have the male and female genes come from different parent plants, a process known as cross fertilization. Now comes the tricky part. Plants are, for the most part, stationary. They can't just get up and walk over to a potential mate. Pollination usually relies on a third party to be the carrier, taking the pollen from one plant to another. These third parties are the great pollinators, and their activities are critical for the survival of most organisms on earth today.

Eleanor Welshon

Pollen must be received by a flower's stigma in order to produce seeds.

Many ancient plants relied on wind to carry pollen. These plants, such as pine trees and grasses, cast large numbers of lightweight pollen grains into the air on the chance that at least some will be received downwind by receptive

Whitney Cranshaw

An earwig may pollinate a blossom through the simple act of seeking shelter from the daylight.

female flower parts of the same species. Such pollen is responsible for many allergies, the stuff of sneezes. Of the flowering plants in the world today, less than 10 percent rely on this "inexpensive" yet risky method of pollination. Most flowering plants depend on a more reliable method of pollen delivery, employing the help of animals.

Birds, especially hummingbirds, and some mammals such as bats, help to provide pollinating services. However, only about one-half of one percent of all flowering plants worldwide rely on these vertebrate pollinators. Since insects account for far more than 50 percent of all species of living organisms, it is little wonder that they are responsible for pollinating most flowering plants.

However, insects do not altruistically pollinate flowers in order to make seeds. In fact, they are undoubtedly unaware of the service they are providing. Insects are attracted to flowers because of their valuable rewards.

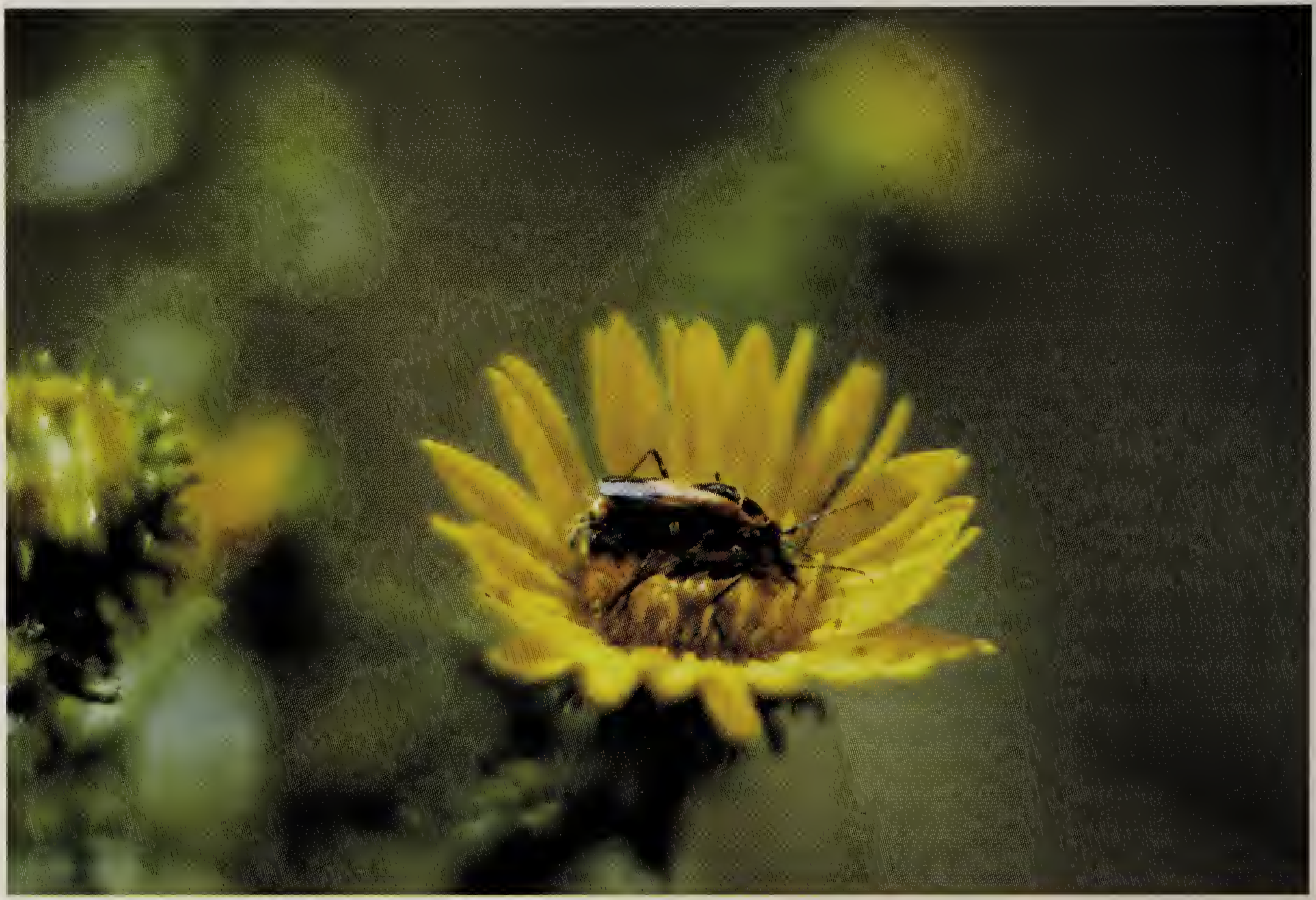
Some plants offer nectar, a sweet fluid high in carbohydrates, vitamins and amino acids. Many insects live exclusively on this elixir during certain phases of their life cycle. Each flower provides only a small amount of nectar, forcing the pollinator to visit many flowers in order to obtain a meal. As insects feed on a flower's nectar, pollen typically adheres to their bodies, and may be distributed to other flowers enabling cross pollination.

Pollen itself is a high protein food source for some insects and most pollinators that collect pollen for food leave at least some behind when going from flower to flower. Some flowers also offer chemicals or waxes that may benefit the pollinator. Some insects are just attracted to the flower as shelter from the weather. For other pollinators, the flowers provide a place to meet a mate, thus serving as a type of "insect singles bar," that attracts like insects which in turn carry pollen to similar flowers.

For the plant, the best pollinators are those that specialize in just a few species of flowers. This increases the likelihood that their pollen will make it to the stigma of another flower of the same species, and that the incoming pollen will also be from a plant of their own kind. Through time, natural selection has caused plants to offer a wide variety of flower adaptations in order to advertise or attract certain pollinators. Simultaneously, insects have also evolved to take advantage of the benefits offered by the flower and successfully compete with other potential pollinators. This "co-evolution" in its extreme form has resulted in some species of flowers that rely on a single or very few species of insect pollinators, and insects that rely on a single species of plants for their survival. When either the plant or the pollinator goes extinct, the other is likely to follow.

Often it is possible to predict what kind of insect a flower will attract by looking at the shape of the flower, color of the petals, time of bloom (both time of season and time of day), fragrance and the rewards offered. While these attributes may be designed to favor a specific kind of insect, most plants are pollinated, at least in part, by other types of insects as well.

It is also important to remember that insects sense the world around them differently than humans do. For example, a flower that seems to lack scent to us may be emitting a chemical that can be detected by an insect pollinator. Also, many insects, including bees and butterflies, can see light in ultraviolet wavelengths which are invisible to humans. Some flowers that look plain to us actually display patterns in utlraviolet light that direct the pollinator to nectar and pollen



Michael Weissmann

Soldier beetles, a common pollinator, are seen here mating on gumweed.

rewards at the center of the flower.

One-fourth of all the known animal species on earth are beetles. Since there are so many kinds of beetles, the number of species that are attracted to flowers is great, making it difficult to generalize about the kind of flowers that attract them. However, most beetles that visit flowers, like the familiar soldier beetles found on gumweed (*Grindelia* spp.) and goldenrod (*Solidago* spp.) in the fall, feed mainly on pollen and some nectar. They often meet their mates at these flowers. They prefer flowers that are flat and offer rewards of large amounts of pollen. Some of the smaller beetles seek out blossoms that are bowl-shaped and offer shelter from wind and weather. For beetles that fly after sunset, night-blooming flowers that produce a strong odor are favored for ease of location in the dark.

Some beetles, like the checkered beetles, are predators and come to the flowers to find food in the form of small flies or other small pollinators. Even these predators are unwitting pollinators as the pollen clinging to their hairy bodies is carried to other flowers as they search for prey. Of the plants that are pollinated by insects, at least 88 percent are pollinated occasionally by at least one species of beetle.

Many people go to great lengths to attract butterflies to their gardens

Butterfly Pavilion and Insect Center

The butterfly is among the most familiar of plant pollinators, yet plays a minor role.

David Inouye

A white-lined sphinx moth feeding on the nectar of a gentian flower.

although they are minor pollinators compared to beetles. Still, there are many plants that have evolved to attract butterflies as their primary pollinator. Since butterflies must be vigilant for predators, they generally prefer flowers that are open, like the composites (such as asters), which allow them to have a wide view while they feed. Clusters of small flowers, such as those found on lilac (*Syringa* spp.) and butterfly bush (*Buddleia* spp.) are also preferred. Most butterflies feed mainly on nectar, and flowers that attract them usually emit a sweet smell to advertise this sugary reward.

Butterflies see color, and are especially attracted to flowers that are red, blue and yellow. Most flowers that produce large amounts of nectar store it in tubular blossoms. Flowers specialized in attracting butterflies have openings too narrow for entrance by bees or most beetles. The butterfly's straw-like proboscis, or tongue, is well adapted to reach inside the tube to extract nectar that is too deep for most other insects to reach.

Flowers that are shaped to attract butterflies but don't open until after dark are well adapted for pollination by hawk moths (or sphinx moths). While their flight and movements resemble those of hummingbirds, hawk moths fly at dusk or night and hummingbirds fly by day.

Anyone who has grown tomato plants is probably familiar with the tomato hornworm, a caterpillar of a common hawk moth. The adult hawk moth drinks nectar from flowers such as gentian (*Gentiana* spp.) and nasturtium (*Tropaeolum majus*), and is a graceful addition to the sunset activity of a flower garden. Many people curse the caterpillars that eat their tomato plants. Wise gardeners grow a few extra plants for the hornworms in order to continue to enjoy the hawk moths at the flowers each evening. After all, the larval stage, otherwise known as a caterpillar, is required to produce butterflies and moths. Next time you think you see a hummingbird at sunset, look again. It is likely the white-lined sphinx moth, a common evening pollinator in regional gardens.

Many flies feed on pollen and nectar too and are therefore, significant pollinators. Most are bee or wasp-like in appearance. Although they don't have a stinger for defense like the bees or wasps that they mimic, predators are fooled into leaving them alone. Syrphid flies, also called flower flies, provide an added benefit for the flowers, as their larvae are predators of some pests. Some flowers, like pipevines (*Aristolochia durior*), give off an odor like dung or rotting meat to attract flies in search of a meal or egg-laying site. These flowers offer no reward and are pollinated by deception.

David Inouye

Syrphid fly adults act as pollinators; the larvae are predators of some pests.

Michael Weissmann

The familiar honeybee was brought to the United States from Europe by the early settlers.

There are more than 400 species of native bees in the Rocky Mountain region, including bumble bees, solitary bees, leaf-cutting bees, sweat bees and many others. Bees usually collect pollen and nectar, and prefer flowers that are flat and open. When visiting a flower, the pollen sticks to their hairy bodies. Most bees use specialized combs on their front legs to compact the pollen into baskets on their hind legs or abdomen. Some pollen always remains behind on the hairs and is scattered on the flowers they visit. Many bees favor a few species of flowers and their emergence as adults is timed to coincide with the blooming of these flowers. Certain flowers can only be successfully pollinated by bumble bees, using a strategy called buzz pollination. Their pollen can be dislodged from the stamens of the flower only when vibrated by the strong buzzing of these large bees.

The classic insect pollinator that comes to mind for most people is the European honeybee. Humans have domesticated bees to make honey and produce wax since before the pyramids of Egypt were built. When European settlers came to this country, they brought honeybees with them. In addition to the products they produce directly, the pollination activity of honeybees is essential to the multi-billion-dollar agricultural industry.

Honeybees are general feeders and collect nectar and pollen from a wide variety of sources. Also, their complex social structure separates working roles so that those responsible for foraging don't reproduce. These attributes have allowed honeybees to thrive in North America, often giving them a competitive edge over native bees. Today, honeybees can be found visiting a wide variety of native flowers, even though most of those evolved with native bees as their primary pollinators.

Our way of life is extremely dependent upon pollination for the food we eat and for other plant-derived products. However, this critical interaction is threatened. Mites and diseases have lead to a drastic decline in honeybee populations. This, combined with the introduction of Africanized ("killer") bee genes into some domestic populations in the South (which causes honeybees to be more aggressive), has led many hobbyist beekeepers to drop out of the bee business.

Destruction of wild habitats, pesticide use and years of competition between honeybees and wild pollinators has in many cases reduced the numbers of wild pollinators to a level where they are unable to make up for the loss of honey bee pollination. Habitat destruction has also resulted in isolated plant populations to the extent that even if pollinators were present, plants of the same species are located too far apart for cross fertilization to likely occur.

However, the potentially bleak future is avoidable through conservation projects that preserve and restore native habitats. Also, replacing at least a portion of a "grow-it to mow-it" grass lawn with a pollination garden will enhance the local habitat for pollinators. Grow a wide variety of plants with blossoms full of nectar and pollen and make sure that at least some are in bloom throughout the entire season. Create pesticide-free plantings that will encourage pollinators to feed, nest and reproduce in your yard.

Most people divide the insect world into good bugs and bad bugs. Even entomologists speak of "pest" insects as those who compete directly with us for resources, and "beneficial" insects as those that provide us with products (wax, silk or honey), eat pest species or pollinate our crops.Yet beneficial doesn't even begin to describe the importance of pollinators, not only to us but also to all other organisms. Perhaps the pollinators should be given a category of their own — the essential insects.

AUTHOR BIOGRAPHY

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GARDENING TO ATTRACT BUTTERFLIES AND BENEFICIAL INSECTS

David M. Ennis

Beds of ornamental grasses and flowers can replace lost insect and small animal habitat.

While uninformed homeowners may assume that all "bugs" should be vanquished from their yards in order to protect landscape plants, savvy gardeners understand the benefits insects and their relatives provide in their backyard habitats. Insects' most obvious roles are those as pollinators of flowers and predators of other insect pests. Some of their less appreciated functions include acting as decomposers by eating plant material to help break down organic matter, aerating the soil, feeding on weeds and weed seeds, and providing a food source to attract birds to the garden — a beneficial role that can be played by even the most undesirable insect pest.

Nearly everyone wants to attract birds and butterflies to their gardens, yet have you noticed fewer butterflies than you did just a few years ago? Your observation is probably correct. The construction of new houses, shopping centers and other commercial development has eliminated the habitats that butterflies, small animals and insects need to survive and reproduce. Landscapes of manicured lawns and crushed rock have in many instances replaced a prairie or other natural habitat which contained plants to support wildlife.

However, with some planning, the habitat lost to development can easily be replaced by gardens that include plantings that encourage a full range of insect and animal life. Aquatic or wetland gardens, water-smart or xeric landscapes and even

by George Brinkmann

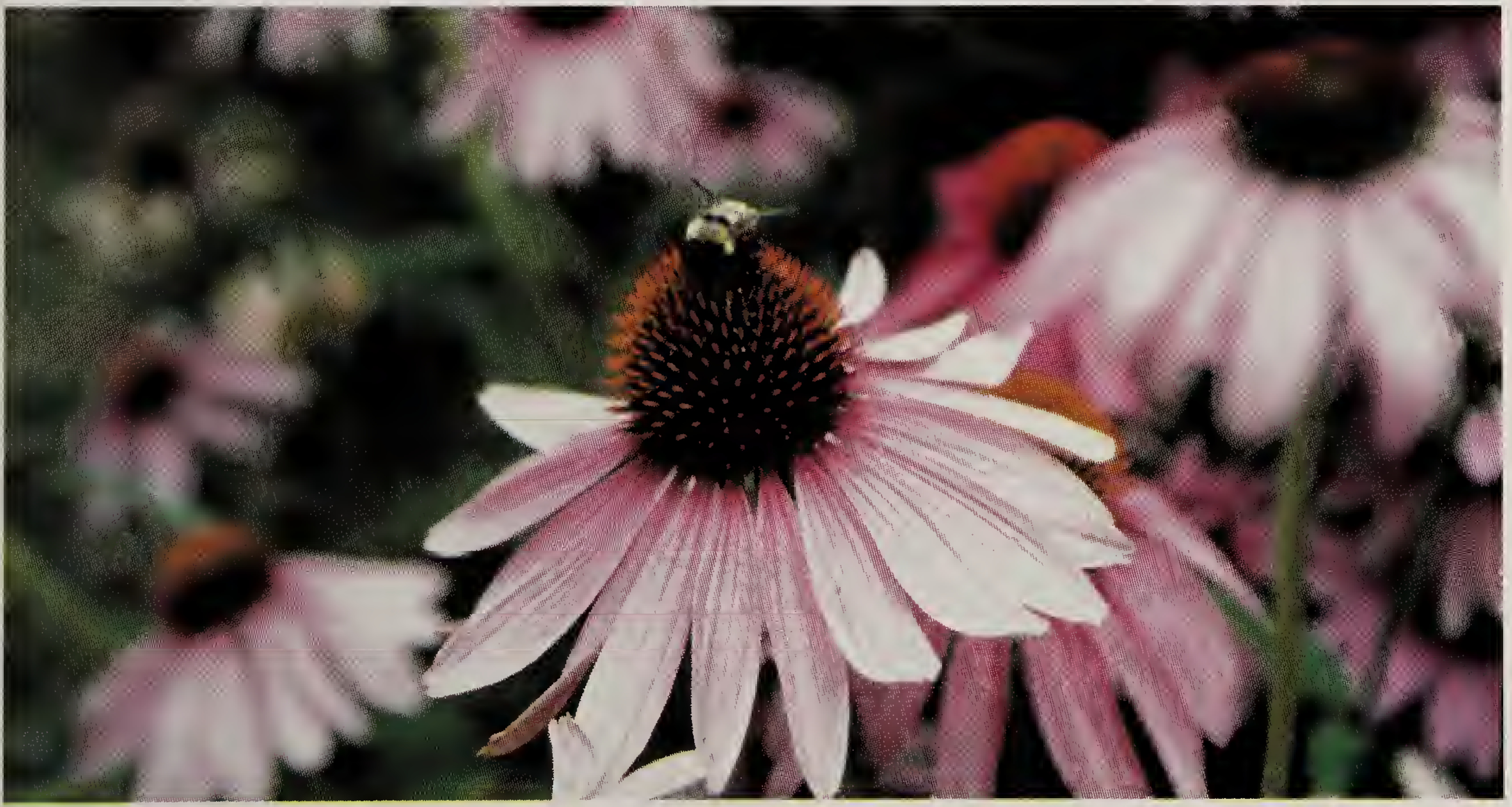
container gardens on your patio can help to replace lost insect habitat. The key is to be clear about what you want to achieve and to combine the principles of plant ecology with good design.

The largest percentage of lost habitat regionally is that of the prairie or grassland. Although the "prairie garden" style is slowly gaining in popularity regionally, its principles are applicable to such traditional garden styles as the perennial border.

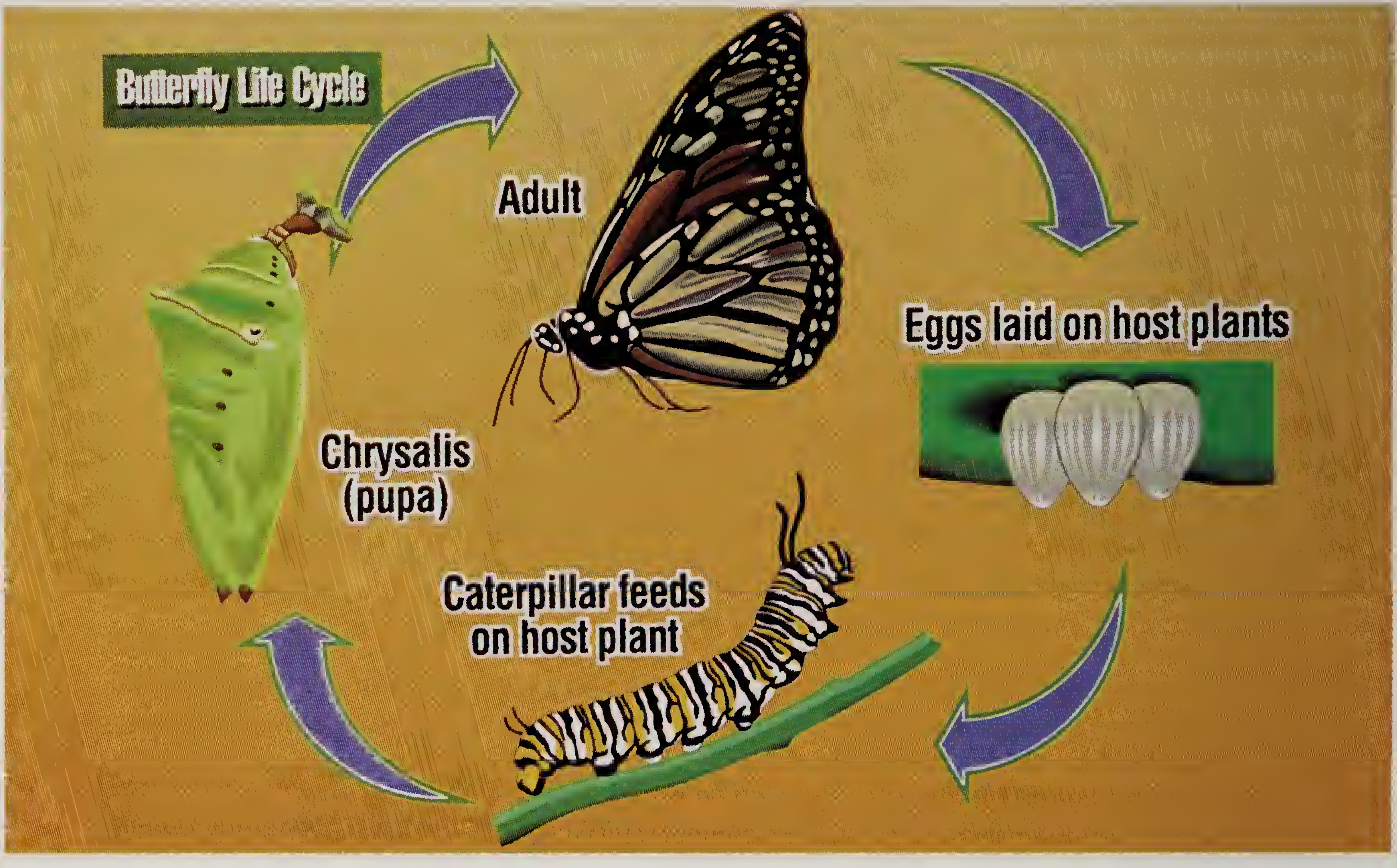
The natural and complementary combination of grasses and wildflowers planted together is the essence of the prairie. To successfully plan such a garden, be sure to select plant species that grow to a size that suits the scale of your landscape.

If your goal is a native version of the prairie, grasses such as big bluestem (*Andropogon gerardii*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*) and sand dropseed (*Sporobolus cryptandrus*) may be good options. These are clump-forming grasses that allow room between them to plant flowers. Wildflowers mix well with grasses and the grass foliage serves as a natural background that accentuates wildflower forms. The flowers and seed heads produced by grasses also attract insects and add a graceful dimension to the planting.

Wildflowers should be planted in masses to create impact and species chosen to provide for a succession of bloom throughout the growing season. Spring bloomers such as flax (*Linum perenne* ssp. *lewisii*), lupine (*Lupinus* spp.), beardtongue (*Penstemon* spp.) and violet (*Viola* spp.) are out of bloom by mid-summer and may be succeeded by late-season flowers such as blazing star (*Liatris punctata*), coneflower


Julie Behrens

Echinacea purpurea, *or purple coneflower, is very attractive to many insects.*



Butterfly Pavilion and Insect Center

The butterfly life cycle averages nine to 13 weeks depending on the species.

(*Rudbeckia* spp.) and prairie coneflower or Mexican hat (*Ratibida columnifera*) to provide food and shelter for insects and wildlife.

The perennial border is a popular option because it fits into the landscape of many urban communities. The style usually incorporates a mixture of flowers, grasses and shrubs. These plants should be planted in clusters of the same type, rather than individual plants, so that it is easier for the butterflies to locate and access their favorites.

Most caterpillars are specific about the plants on which they will feed and female butterflies will often lay their eggs only on a specific food plant. To enhance the perennial border's attractiveness to butterflies and beneficial insects, include those plants that are necessary or are perhaps a food source for them at some part of their life cycle, whether as a larva or adult.

Nectar-producing plants should be chosen with attention to variety in flower color and plant height and should bloom at different times of the growing season. Veronica (*Veronica* spp. and cvs.), butterfly weed (*Asclepias tuberosa*) and blanket flower (*Gaillardia* cvs.) are among the best for attracting butterflies.

In addition to providing food sources, it is important to provide for butterfly shelter during windy and stormy weather. They also need sites to roost during cloudy weather and at night. Butterfly bush (*Buddleia* spp.) is not only a great nectar source, but can provide shelter too.

Another tip is to incorporate large boulders or rocks into your garden scheme to provide butterflies with a spot to bask in the sun.

Since butterflies appreciate warm, sunny sites, they are often seen around xeric and water-smart plantings. The hardy cacti often used in these gardens produce bright flowers that attract honeybees and other small predatory wasps and flies to gather pollen. The flowers of succulent plants provide nectar for butterflies, tiny wasps and syrphid flies that are natural predators of aphids and other garden pests.

Water-smart gardens are not limited to cacti and succulents. Flowers that provide nectar sources yet require less water include beardtongue (*Penstemon* spp.), pinks (*Dianthus* spp.), giant hyssop (*Agastache* spp.) and verbena (*Verbena* spp.).

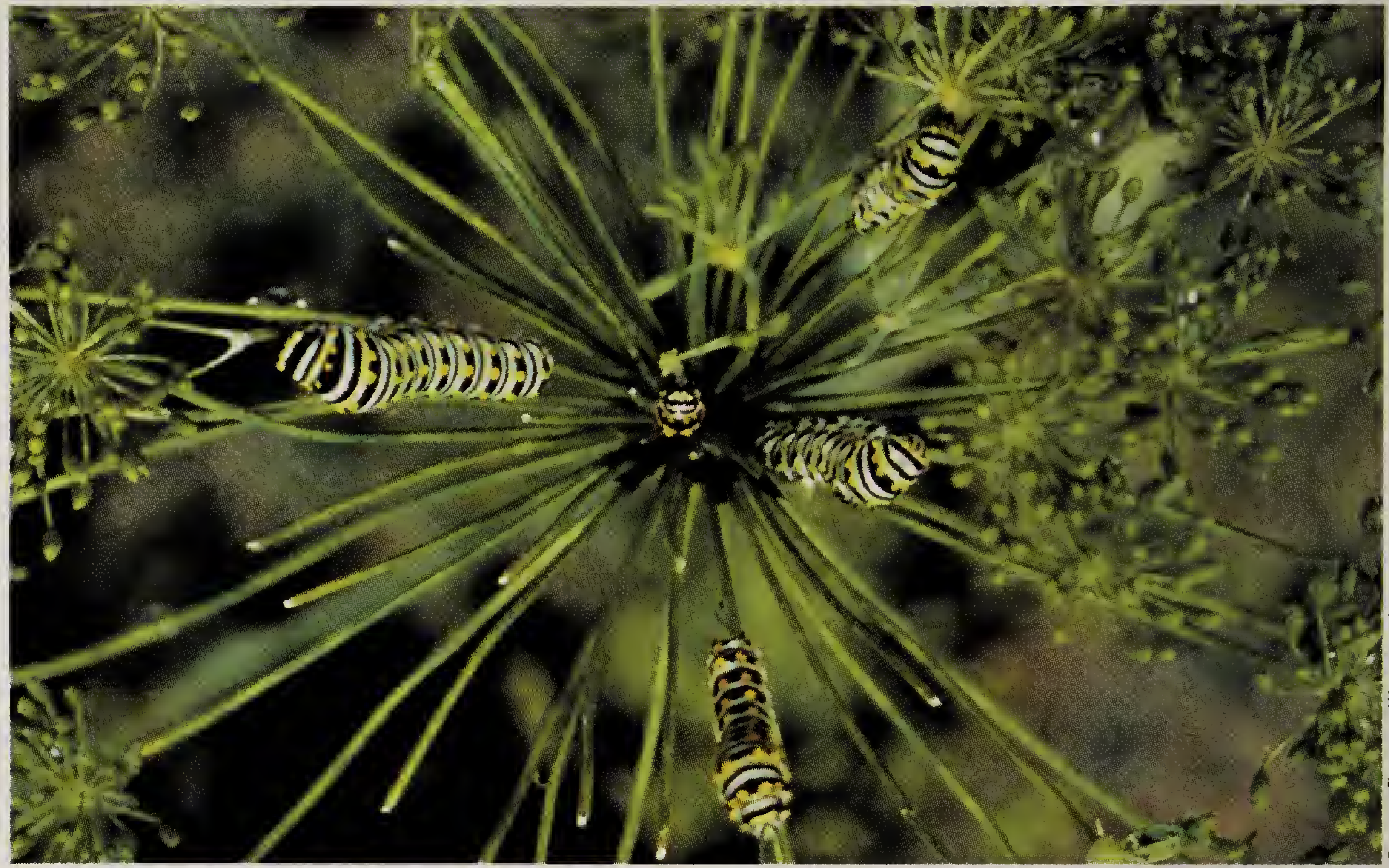
David M. Ennis

The bright flowers of cactus attract many pollinators.

Even specialty gardens, such as herb gardens, have many opportunities to replace lost habitat and encourage butterflies and beneficial insects. Again, plant selection is key. Popular herb garden varieties that also frequently appear in perennial border plantings include lavender (*Lavandula* spp.), thyme (*Thymus* spp.), mint (*Mentha* spp.), oregano (*Origanum* spp.), chives (*Allium schoenoprasum*), borage (*Borago officinalis*) and sage (*Salvia* spp.). All these are attractive to butterflies, bees and predatory insects because of their flower shape, size and nectar properties.

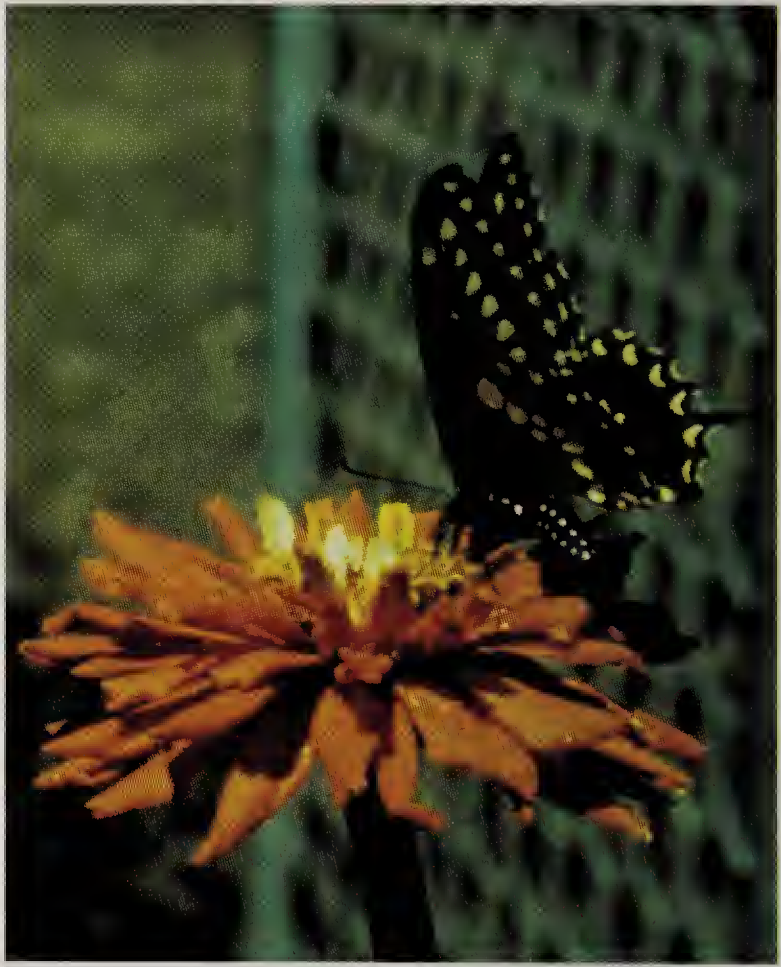
Herb garden plants are also useful and popular subjects for container gardening. Container herb gardens should be sited in full sun and include a variety of types that might provide nectar for the longest possible period of the growing season. In order to attract butterflies and beneficial insects, the herbs must be allowed to flower, an activity that many herb gardeners unfortunately nip in the bud.

The wildlife habitat that has been lost to urban development, including that for butterflies and beneficial insects, can be replaced through a variety of options in garden and landscape plantings. All it takes is some forethought and the realization that it is an on-going process that may challenge your imagination and gardening strategy for many years.


Butterfly Pavilion and Insect Center

Black swallowtail (*Papilio polyxenes*)

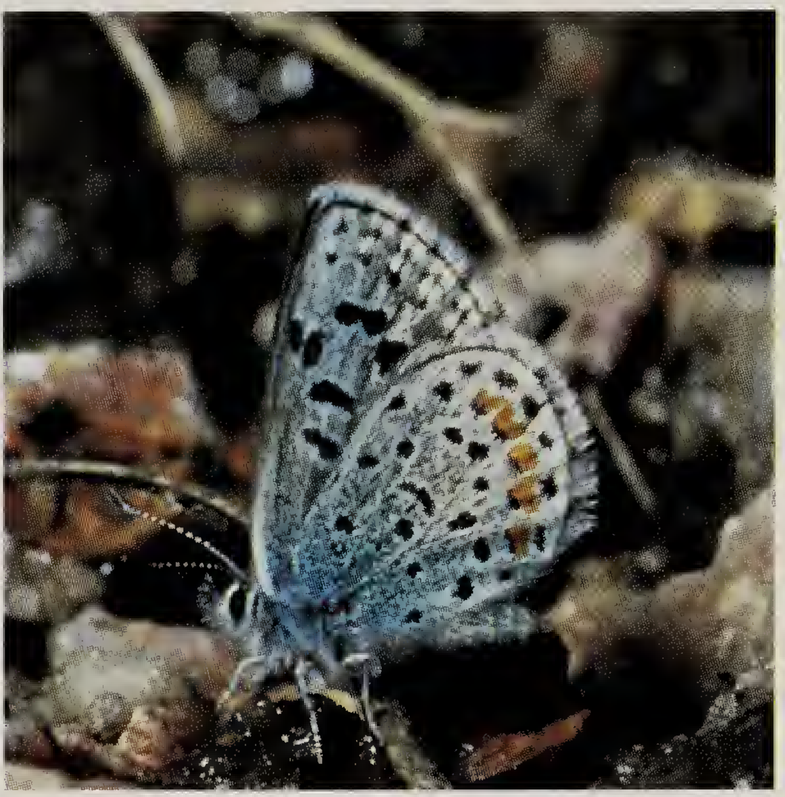
Black swallowtail, the most abundant swallowtail butterfly in North America, is predominately black in color. The males have a band of yellow spots across the lower middle of both pairs of wings. It is found almost everywhere and is especially common in vacant lots and gardens where its host plants grow. Its green caterpillars have black bands with orange or yellow spots and feed on dill, parsley, carrot, fennel and other plants in the carrot family. Adults are attracted to many flowers including verbena, zinnia, butterfly bush and milkweed (*Asclepias* spp.).


Butterfly Pavilion and Insect Center

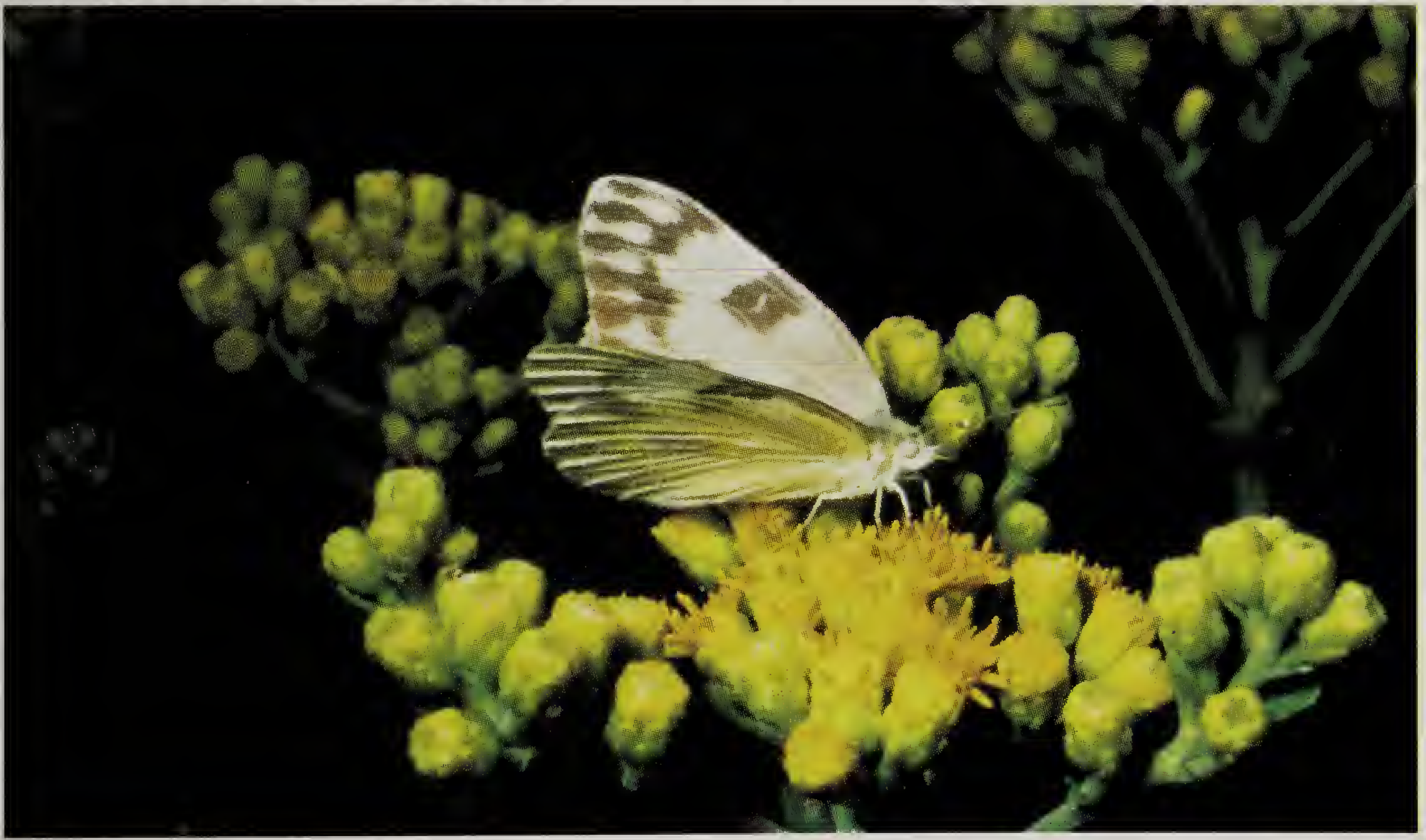
The larval and adult forms of the black swallowtail.

Melissa or Orange-bordered blue (*Lycaeides melissa*)

The male of this species is a lovely lilac blue with a narrow black border and white fringes. The female is brown, often glossed with blue and has a wide band of orange on the hindwing. This species is most commonly seen in open fields, roadsides, vacant lots and mountain meadows where lupine, alfalfa (*Medicago sativo*), milk vetch (*Astragalus* spp.) and wild licorice (*Glycyrrhiza* spp.) grow.



Butterfly Pavilion and Insect Center



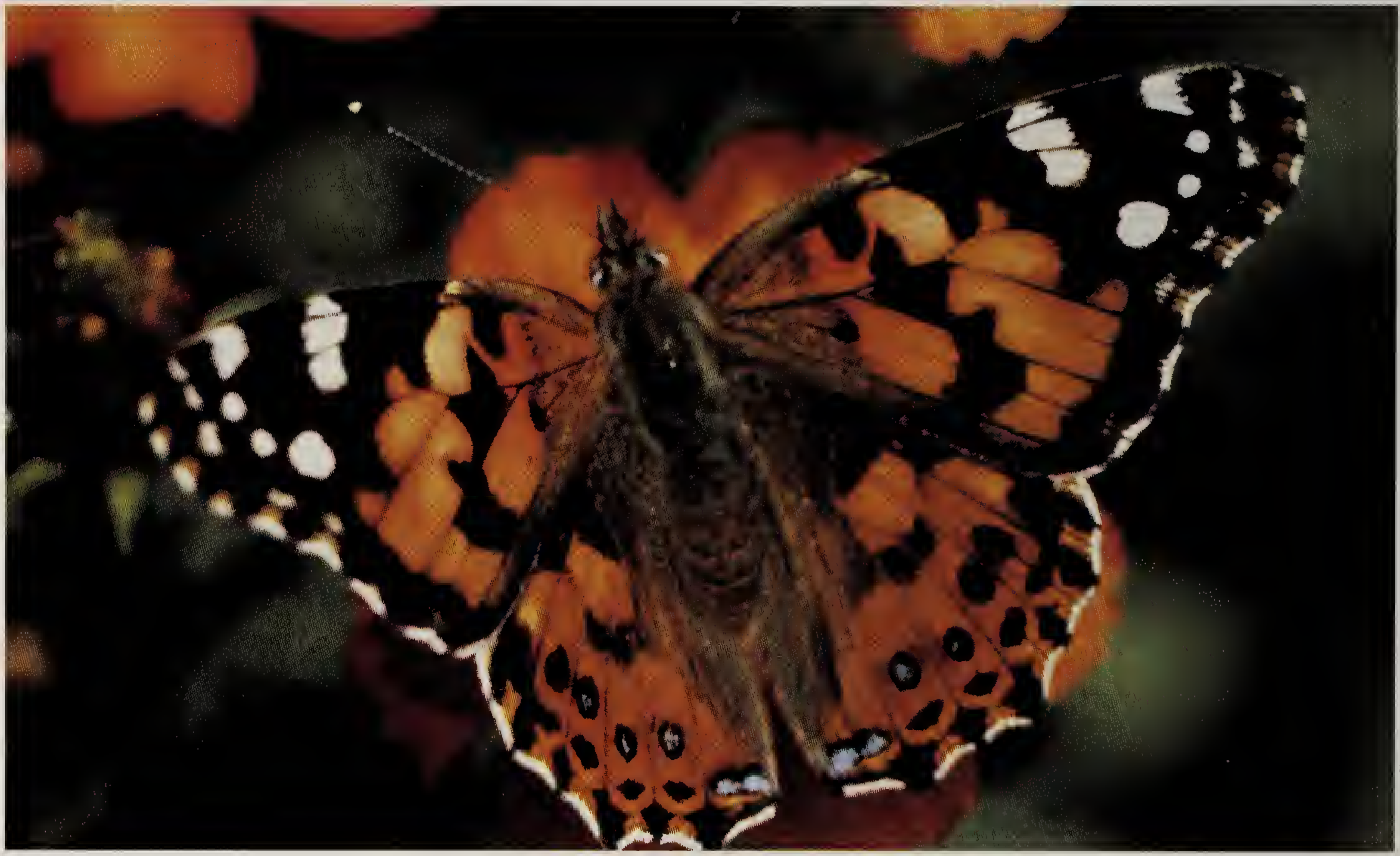
Butterfly Pavilion and Insect Center

Checkered white (*Pontia protodice*)

A common white species with a distinctive forewing cell bar and lacking a dark spot in the lower outer edge of the forewing. They can be found flying in vacant lots, fields, roadsides, etc. The green and black caterpillars feed on many plants of the mustard family as well as spider flower (*Cleome hassleriana*). Nectar plants include alfalfa, clover and field bindweed.

Painted lady (*Vanessa cardui*)

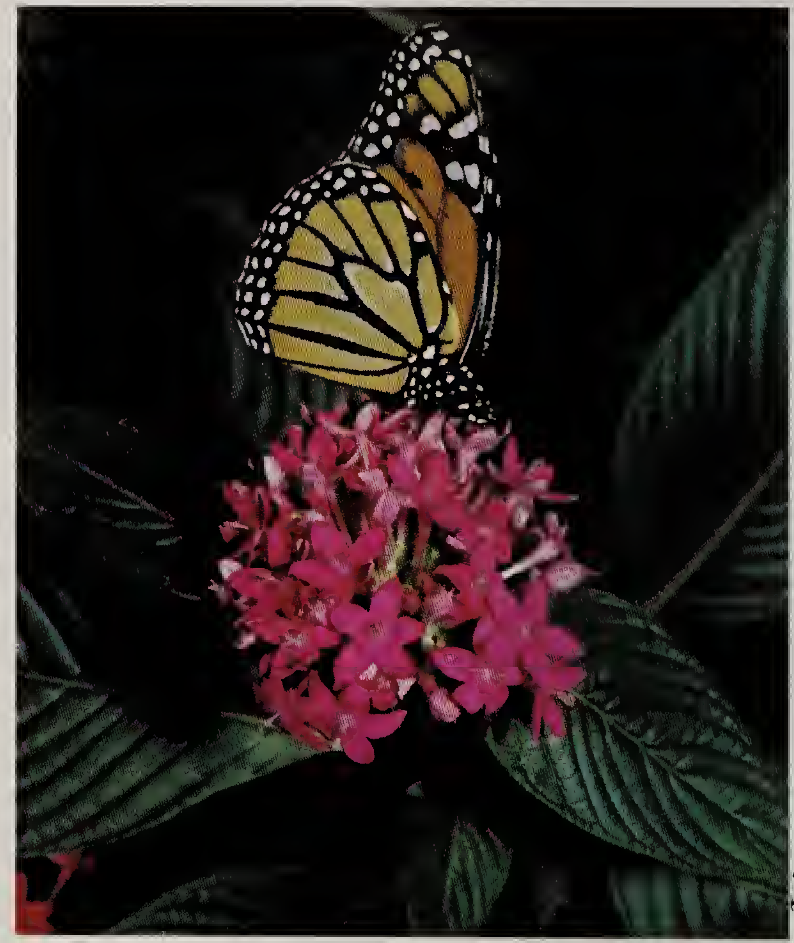
This species has large population explosions in some years. The basic color is pinkish-tawny with dark brown to black markings. It is found everywhere. Its hairy caterpillars feed on thistle and various mallows (*Malva* spp.). Adults are often seen in late summer feeding on verbena, rabbitbrush (*Chrysothamnus* spp.), butterfly bush, zinnia and Mexican sunflower.



Butterfly Pavilion and Insect Center

Monarch (*Danaus plexippus*)

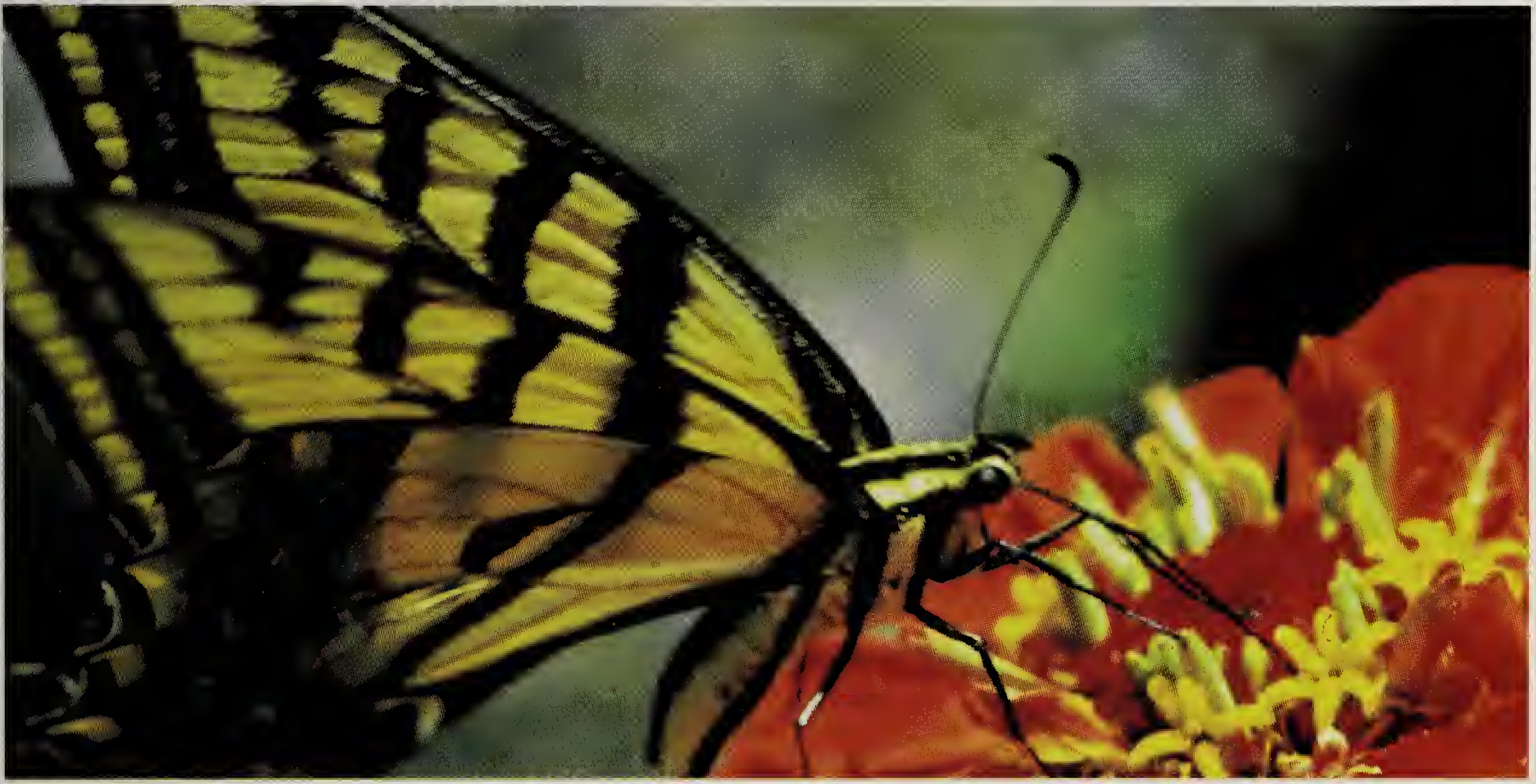
The monarch's distinctive orange, black and white wing pattern helps warn predators, particularly birds, to leave it alone. Its white, black and yellow-striped caterpillars feed on milkweed and occasionally dogbane (*Apocynum* spp.). The monarch can be commonly encountered in open fields, meadows, roadsides, yards, parks and gardens. Adults may be found in late summer feeding on verbena, butterfly bush, rabbitbrush and Mexican sunflower as they make their migration to central Mexico.



Don Jarrett

Two-tailed swallowtail *(Pterourus multicaudatus)*

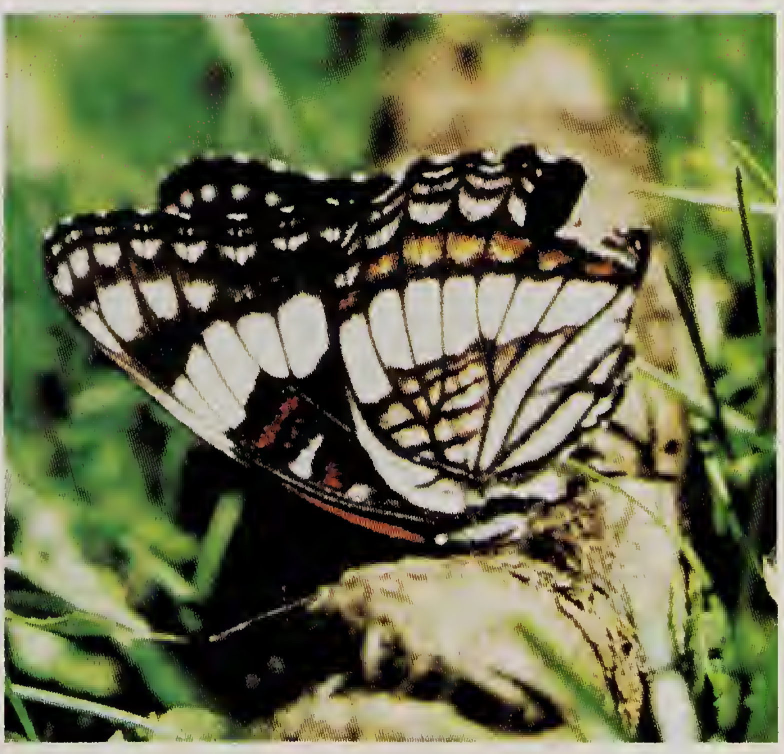
Distinguished by two tails on each hindwing, this species is found along streamsides, in moist valleys of arid areas, woodlands, groves and parks throughout our area. The green caterpillars have a pair of eyespots near the head and are seen on ash trees (*Fraxinus* spp.), cherry (*Prunus* spp.), serviceberry (*Amelanchier* spp.) and hoptree (*Ptelea trifoliata*). The adults are attracted to verbena, butterfly bush and thistle.



Butterfly Pavilion and Insect Center

Weidemeyer's admiral (*Limenitis weidemeyeri*)

This distinctive black butterfly has a white median band and occurs in deciduous forests of mountain areas, along streamsides and on the edges of coniferous forests. Its caterpillars resemble bird droppings with a pair of horns near the head and feed on poplar, cottonwood and aspen (*Populus* spp.) as well as willow (*Salix* spp.). Adults are often seen sipping water along streams.



Butterfly Pavilion and Insect Center

Garden Plant List

Perennials

***Achillea millefolium* (common yarrow)**
Good nectar source, especially for small butterflies such as skippers and coppers. Long season of flowering.

***Agastache rupestris* (sunset hyssop)**
Attracts hummingbirds and butterflies that have a long proboscis such as the tiger swallowtail and monarch. Flowers from summer through fall.

***Allium schoenoprasum* (chives)**
Excellent attraction for butterflies and smaller bees, syrphid flies and predatory wasps. The cultivar 'Forescate' is particularly recommended.

***Asclepias tuberosa* (butterfly weed)**
Both a nectar source and food plant for monarch butterflies and their caterpillars.

***Aster* x *frikartii* 'Wonder of Staffa' (Wonder of Staffa aster)**
Provides nectar and pollen for butterflies and bees. One of the best asters because of its long flowering period from June until frost.

***Centranthus ruber* (Jupiter's beard)**
Nectar source for butterflies and small insects. Tolerant of drought and poor soils.

***Coreopsis* spp. and cvs. (tickseed)**
Many are prolific bloomers from late spring until frost.

***Dianthus* spp. (pinks)**
One of the best nectar sources for butterflies and moths.

***Echinacea purpurea* (purple coneflower)**
A great nectar source for butterflies and bees.

***Eupatorium purpureum* (Joe Pye weed)**
A good nectar source from late summer to frost.

***Gaillardia* spp. and cvs. (blanket flower)**
Nectar and pollen source for butterflies and bees.

***Helenium autumnale* (sneezeweed)**
Provides both nectar and pollen for butterflies and bees. Drought and heat tolerant.

Don Jarrett

***Helianthus maximilianii* (Maximilian sunflower)**
Important food for wildlife. Provides protein from seeds and nectar from flowers. A September-blooming Great Plains native.

***Liatris punctata* (blazing star)**
Attracts painted lady and monarch butterflies migrating in late summer. Native to the dry soils of the western prairies.

Butterfly Pavilion and Insect Center

***Lychnis chalcedonica* (Maltese cross)**
Good nectar source in midsummer.

***Mentha spicata* (spearmint)**
Attractive to bees, predatory wasps, syrphid flies and butterflies.

***Monarda didyma* (bee balm)**
Good nectar source for bees and butterflies in summer and fall.

David M. Ennis

***Nepeta* x *faassenii* (catmint)**
Attracts small predatory insects.

***Penstemon* spp. (beardtongue)**
Numerous species and varieties provide good food sources for hummingbirds and butterflies.

***Rudbeckia fulgida* (orange coneflower)**
Butterflies and bees are attracted to its nectar and pollen.

***Scabiosa columbaria* (pincushion flower)**
A constant nectar supply all summer.

***Sedum* cvs. (stonecrop)**
Butterfly and bee nectar source. Useful in sunny, dry locations.

***Verbena canadensis* (rose verbena)**
Excellent nectar source that is marginally hardy.

***Veronica* spp. (speedwell)**
Numerous species and cultivars are excellent sources of nectar.

Annuals

***Lantana montevidensis* (trailing lantana)**
An excellent nectar provider.

***Pentas lanceolata* (star flower)**
A good nectar source for butterflies.

***Tithonia rotundifolia* (Mexican sunflower)**
One of the best nectar-providing annuals. Painted lady and monarch butterflies love this plant.

***Verbena bonariensis* (purple top)**
An excellent nectar source.

***Zinnia* cvs. (zinnia)**
The best nectar source. Butterflies cannot stay away from the vividly colored cultivars 'Scarlet Splendor' and 'Splendor Mix.'

Herbs

***Anethum graveolens* (dill)**
The use of this plant in your garden will ensure a population of the black swallowtail butterfly.

***Salvia officinalis* (garden sage)**
Attractive to bees and butterflies. Drought resistant.

***Thymus vulgaris* (common thyme)**
Attracts many small predatory insects as well as butterflies.

AUTHOR BIOGRAPHY

George Brinkmann has a degree in horticulture from Colorado State University and has been a grower, wholesaler and retailer in the floral industry. He is a former member of DBG's horticulture staff and is currently the horticulture director at the Butterfly Pavilion and Insect Center in Westminster, Colorado.

ENVIRONMENTALLY FRIENDLY APPROACHES TO INSECT PEST MANAGEMENT

Jim Havey

Denver Botanic Gardens takes a responsible and integrated approach to insect pest management.

Gardening is the number one leisure time activity in the United States. As more and more gardeners don their gloves and grab their trowels, there is increased concern about environmentally responsible approaches to gardening. Although gardening is extremely satisfying for the human soul, it is vitally important that we are also good stewards of the land upon which we live. The horticultural staff at Denver Botanic Gardens has embraced this responsibility and takes an integrated approach to insect pest management.

Integrated pest management (IPM) is the practice of employing a variety of environmentally harmonious cultural practices to create a healthy garden. It involves appropriate plant selection, proper cultural methods, using biological controls to minimize insect infestations and, as a last resort, using low-toxicity pesticides.

The key word in IPM is tolerance. Remember when the first organic produce began to appear in the grocery stores? For some reason, many people avoided the organic fruits and vegetables because they were not perfect. They had blemishes and may not have been eye-appealing, despite the fact they were grown without pesticides and were much safer for human consumption. We had no tolerance. In the many years since then, we have grown accustomed to organic produce.

Tolerance is required in the landscape as well. We are an active element of the environment in which we live. All organisms living in this

by Amy Yarger and Julie McIntyre

environment must co-exist in harmony. We must demonstrate tolerance to achieve this balance. This means allowing our garden plants to have insect infestations and diseases, but at a tolerable level. It means not running for pesticides each time you find an insect attacking your favorite plant. Allowing insect populations in your garden will help encourage a natural balance between the pests and the predators.

The IPM policy employed at Denver Botanic Gardens states that plant selection, cultural methods, mechanical controls and tolerance are employed before resorting to pesticides. Pesticides are used only when the health of the plant or plant collection is endangered, and then, only the least toxic, environmentally friendly formulas are used.

A successful, long-term pest management strategy must preserve the diversity of beneficial organisms in the garden. First, become acquainted with the garden's inhabitants. In order to decide upon a course of action, it is necessary to identify friends and foes and environmental factors which are conducive to pest outbreaks. The size and persistence of pest populations may depend upon the numbers of potential invaders, the distance of the invaders from the food plant source, food quality and quantity, and the presence of competitors and predators. One of the best things a gardener can do is to spend time in the garden observing and monitoring conditions.

When natural processes fail to keep insect pests at acceptable levels,

Denver Botanic Gardens

A healthy garden environment with good soil, proper water and fertilization is less vulnerable to pest invasions.

Denver Botanic Gardens

Staff at Chatfield Arboretum have used parasitic nematodes to control cucumber beetles in the pumpkin patch.

Pest Management Profile

Control of the Cucumber Beetle

Two almost microscopic parasitic nematode species were used to help control emerging cucumber beetle larvae in the pumpkin patch at Chatfield Arboretum. The nematodes live in the soil and prey on the larvae by entering the larvae before they emerge from the soil. The nematodes harbor a bacterium that kills their larval host. Applied over a few growing seasons, the nematodes have reduced the cucumber beetle populations by more than 50 percent.

the gardener may choose from a variety of approaches to maintain the health and appearance of the garden. A gardener must establish priorities of pest management based on such factors as safety, cost, effectiveness, length of effectiveness and environmental health. At Denver Botanic Gardens, the goal is to reduce damage in order to maintain plant health and attractiveness. Our choice of pest management strategies reflects concern for our many visitors, both human and non-human.

Altering planting and harvesting schedules, managing irrigation and

Whitney Cranshaw

Hand-picking potato beetles was just one control method employed by Gardens' staff in the Pre-Columbian Garden.

Pest Management Profile

Control of the Colorado Potato Beetle

When Colorado potato beetles were found on potato (*Solanum tuberosum*) and tomato (*Lycopersicon esculentum*) plants in the pre-Columbian Garden, the horticulturist hand-picked some of the beetles, removed leaves with eggs and applied an insecticidal soap. Even with a combination of methods, there was a second wave of beetles, but the population was eventually brought under control with this program and the harvest was not affected.

drainage, fallowing and composting are among the cultural methods that can effectively help manage pest populations. Choosing healthy seed and plants, as well as properly preparing beds, plus fertilizing and watering appropriately are important. Healthy plants are less likely to be vulnerable to pest invasions.

The management of garden pests might begin as early as the design process; the landscape can be planned to promote plant species diversity. Garden design also involves the proper placement and spacing of plants. Awareness of alternate hosts for a particular pest also can contribute to garden health. Thorough inspection of new plants before purchase may go a long way in preventing pest outbreaks later. One of the easiest pest management tactics is to check for any sign of pest activity such as egg masses, galls, chewed leaves or root damage before buying plants.

Continued on page 33

Pest Management Profile

Pest Management in the Boettcher Memorial Conservatory

Jim Havey

One of the first inclinations of a gardener is to worry about the presence of insects on plants. Most gardeners assume that some kind of damage is being done. While controlling plant pests is necessary to some degree in order to promote plant vigor, prevent disease transmission and provide aesthetically beautiful specimens, this does not mean that one should deploy the full arsenal of toxic chemicals to eliminate every bug.

The Tropical Botanica exhibit in the Boettcher Memorial Conservatory after all, is the simulation of a tropical ecosystem, complete with “good” and “bad” bugs. Pest populations kept within controllable limits will not damage plants to an extent which they cannot outgrow. Within the exhibit, Gardens’ staff has aggressively implemented an IPM program. By establishing a viable population of a pest’s natural enemy it is possible to maintain pest populations within acceptable levels. This creates an ecosystem where pests and predators live in equilibrium.

The primary pests encountered in the Conservatory are also common houseplant pests and include aphid, mealybug, whitefly and scale. These insects are extremely efficient at reproducing and can consequently establish large populations quickly. They are considered phloem feeders, which means that they feed on the sugary carbohydrate that the inner bark tissue (or phloem) transports. One early detection sign indicating the presence of phloem feeders is the appearance of a sticky, shiny exudate, called honeydew, on leaf surfaces, which is the by-product of the pests.

Green lacewings (*Chrysoperla rufilabris*) have been released to control many different types of pests, including aphid, spider mite, whitefly, mealybug and thrip. These general predators, named for their delicate green gossamer wings, consume soft bodied insects and their eggs. Native to the southeastern United States, lacewings may find their way naturally into Colorado gardens during the summer months.

In the Conservatory, both egg and larval stages of lacewings have been introduced to establish a population. When they first hatch, lacewings prey primarily on the egg stage of pests. As the larvae grow, they will feed on other pest life stages. It takes approximately one month for lacewings to mature from an egg to an adult. As an adult, the female can lay up to 600 eggs, each laid individually on the end of a hair-like filament. Adult lacewings are nocturnal and feed on nectar and pollen which must be available to establish a population.

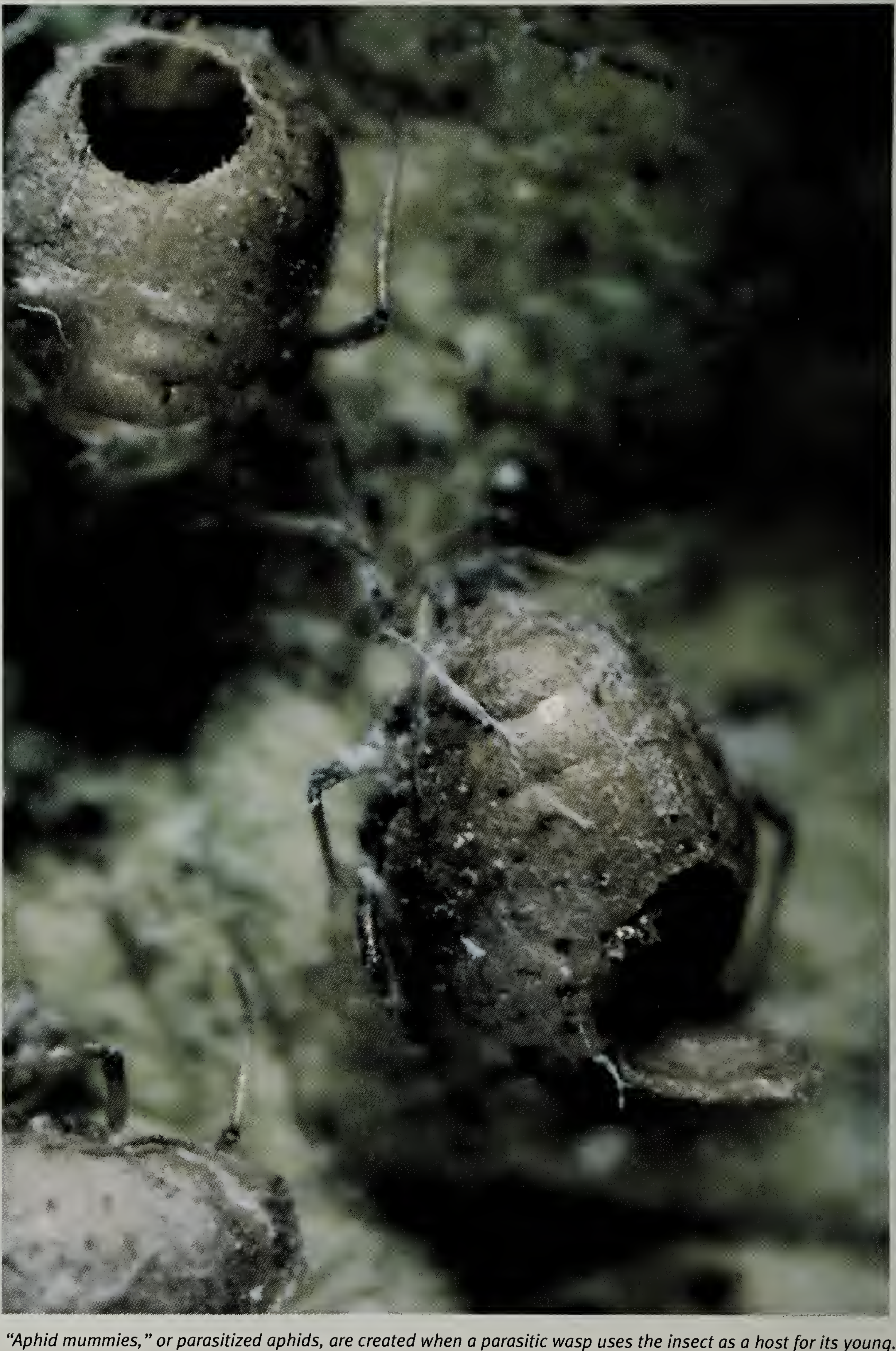
The *Lindorus lopanthae* beetle, a predator with a more specialized diet, was also released. This tiny beetle is smaller than the familiar lady beetle, to which it is closely related. It is black with a reddish-orange head and preys on scale insects. They are wonderful additions to a biological control program because they eat not only eggs and juvenile insects, but also adults of many types of hard and soft scale.

Scale insects have an intermediate metamorphosis that is very similar to that of whiteflies. After hatching, the first instar (development phase), called a “crawler,” is active and wingless, but the remaining preadult instars are sessile and inactive. The last preadult instar, which has external wings, is called the pupa.

Adult beetles lay hundreds of eggs in their lifetime which hatch under the bodies of the scale. Gray, alligator-shaped larvae feed on the eggs of scale and, as they mature, eat the crawler stage of the scale. The beetles will then pupate and emerge as adults, feeding on all stages of the insect, even chewing through the hard outer shell of the scale.

Cryptolaemus beetles, native to Australia, are small, dark brown and have an orange head. Their larvae resemble, and are often mistaken for, mealybugs, but as they develop the larvae are actually larger and whiter. Predator larvae feed on mealybug eggs and larvae, as well as on small aphids and some species of scale. Within the Conservatory, these beetles established them-

Green lacewings were released in the Conservatory to control many different pests.



Butterfly Pavilion and Insect Center

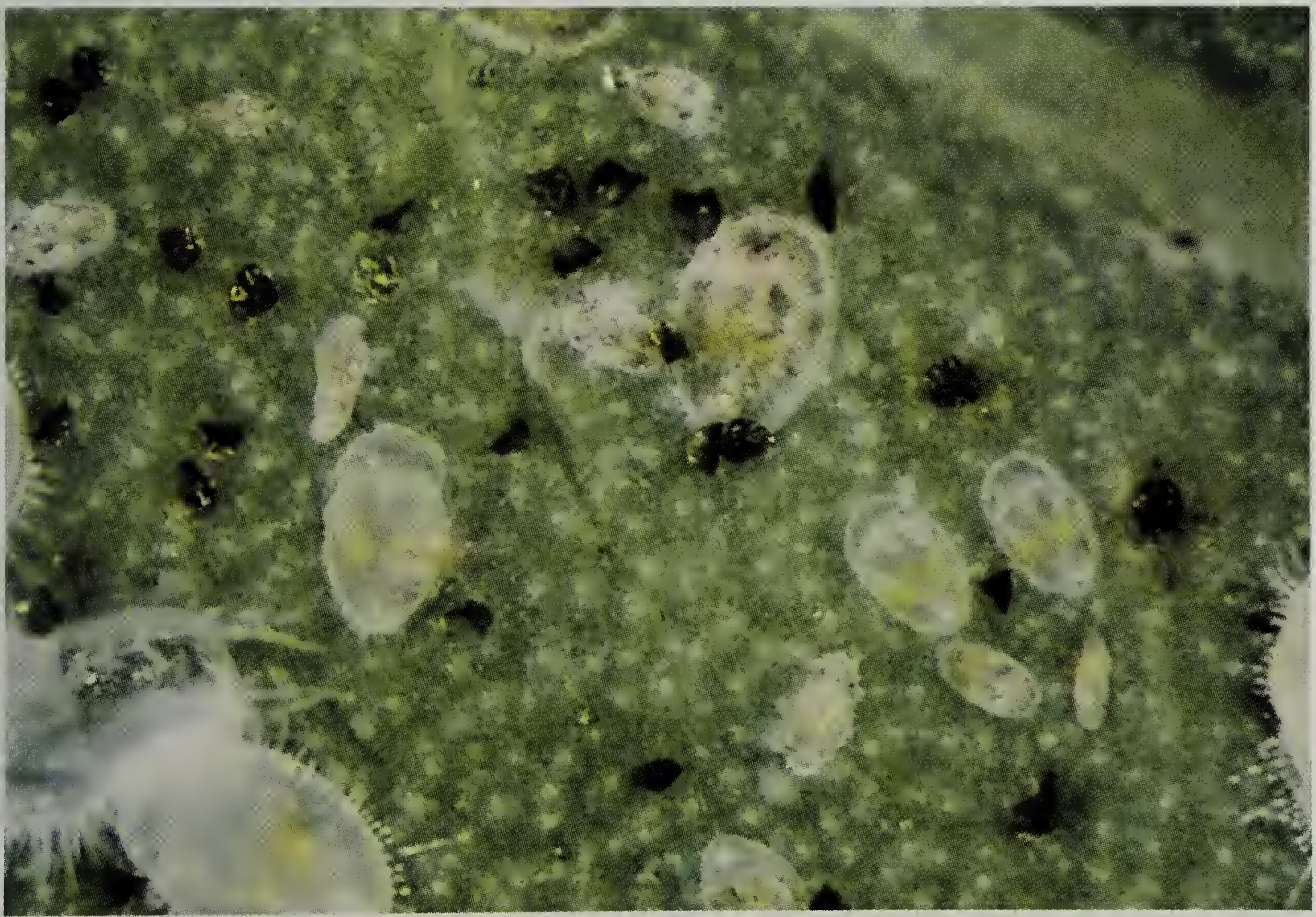
"Aphid mummies," or parasitized aphids, are created when a parasitic wasp uses the insect as a host for its young.

selves and continue to control the mealybug population. It takes longer for the populations of predators to become established than it does for the pests. But, once the populations are stable, they can compete with the quick reproduction of the mealybugs. The two populations will then establish a balance, cycling upward together as growth increases and declining together as populations decrease.

Two parasitic wasps, also known as parasitoids because the larvae develop within another insect, have been released in the Conservatory. *Aphidius colemani* controls aphids and *Eretmocerus eremicus* controls whitefly. *A. colemani* is a small wasp, only two to three millimeters long. The female lays an egg inside the aphid by curling her abdomen forward and stabbing it with her ovipositer. The egg hatches within the aphid and the larva consumes the aphid as food. Upon maturity, the adult wasp cuts a round hole in the aphid and emerges. The parasitized aphid can be identified by its coppery color and by a hole in the dead insect from which the wasp has emerged.

For whitefly outbreaks, *Eretmocerus eremicus*, a small wasp only 0.6 millimeters long has provided very effective control. The female wasp lays her egg under the whitefly nymphs. When the eggs hatch, the larvae move into the young whitefly and develop inside. About 25 days later, the adult wasp will emerge, again cutting a hole in its host to escape.

Both of these parasitoids track their prey using pheromones which the prey produce. Pheromones, sometimes called "social hormones," are chemical scents produced by organisms to communicate with each other. The parasitic wasps follow pheromone trails secreted by the aphids or whiteflies to communicate within their communities.



Whitney Cranshaw

Whitefly has been a problem insect in the Conservatory.

Whitney Cranshaw

Crushing insect egg masses by hand can be a very effective means of pest control.

Denver Botanic Gardens

Microscopic mites have been used in the Plains Garden to control field bindweed.

Pest Management Profile

Mites Used to Weaken Field Bindweed in the Laura Smith Porter Plains Garden

One ongoing study by the Colorado Department of Agriculture involves the use of specific mites to control field bindweed (*Convolvulus arvensis*). These microscopic mites can cause puckering and distortion of the leaves which helps to weaken the plants and slow their growth. In some cases, plants have slowly declined and ultimately died. This may only be partially attributed to the mites; however, any decrease in this stubborn plant's vigor is a victory. Refining this process may lead to a promising solution for the future. Denver Botanic Gardens has introduced these mites in the Laura Smith Porter Plains Garden and will continue to monitor their effectiveness.

Within an IPM framework, one can look at the environment as a whole and solve pest problems accordingly. Identify the specific species of pests, recognize life cycles and growth stages, monitor population levels, and then determine the most appropriate methods of control. This may mean pruning out severely infested and dead portions of plants, mechanically controlling the pest (such as picking them off or spraying them off with high pressure water) or releasing natural predators of the pest. When releasing the natural enemy of a pest it is essential to be able to identify the egg, larval and adult stages of both the pest and its enemy.

Types of biological control organisms may include arthropod predators, parasitoids, pathogens, bacterial or fungal antagonists of plant pathogens and parasitic nematodes.

When other methods are not feasible or effective, and damage exceeds tolerance levels, chemical controls may be implemented. Each gardener must decide which pest control method best suits each situation. Some problems are difficult to control with chemical use and pest populations may develop resistance to chemical pesticides. If you feel you must use pesticides, always be sure to read and carefully follow the label directions.

Before administering pesticides, it is vital to minimize any potential ill effects, such as drift and contamination of surface and ground water. By spot-treating to reduce negative impacts, and timing treatments to be less disruptive to other organisms, one may avoid many of the harmful effects. A low pest population is necessary to maintain a population of natural enemies, so total elimination of the pest is not necessarily desirable.

As you can see, there are a number of alternatives available to manage insects in the landscape. The most vital of them is tolerance. Remember, we have a responsibility to actively preserve the environments we inhabit on earth and, therefore, must make thoughtful decisions toward being exemplary stewards of our land.

AUTHOR BIOGRAPHIES

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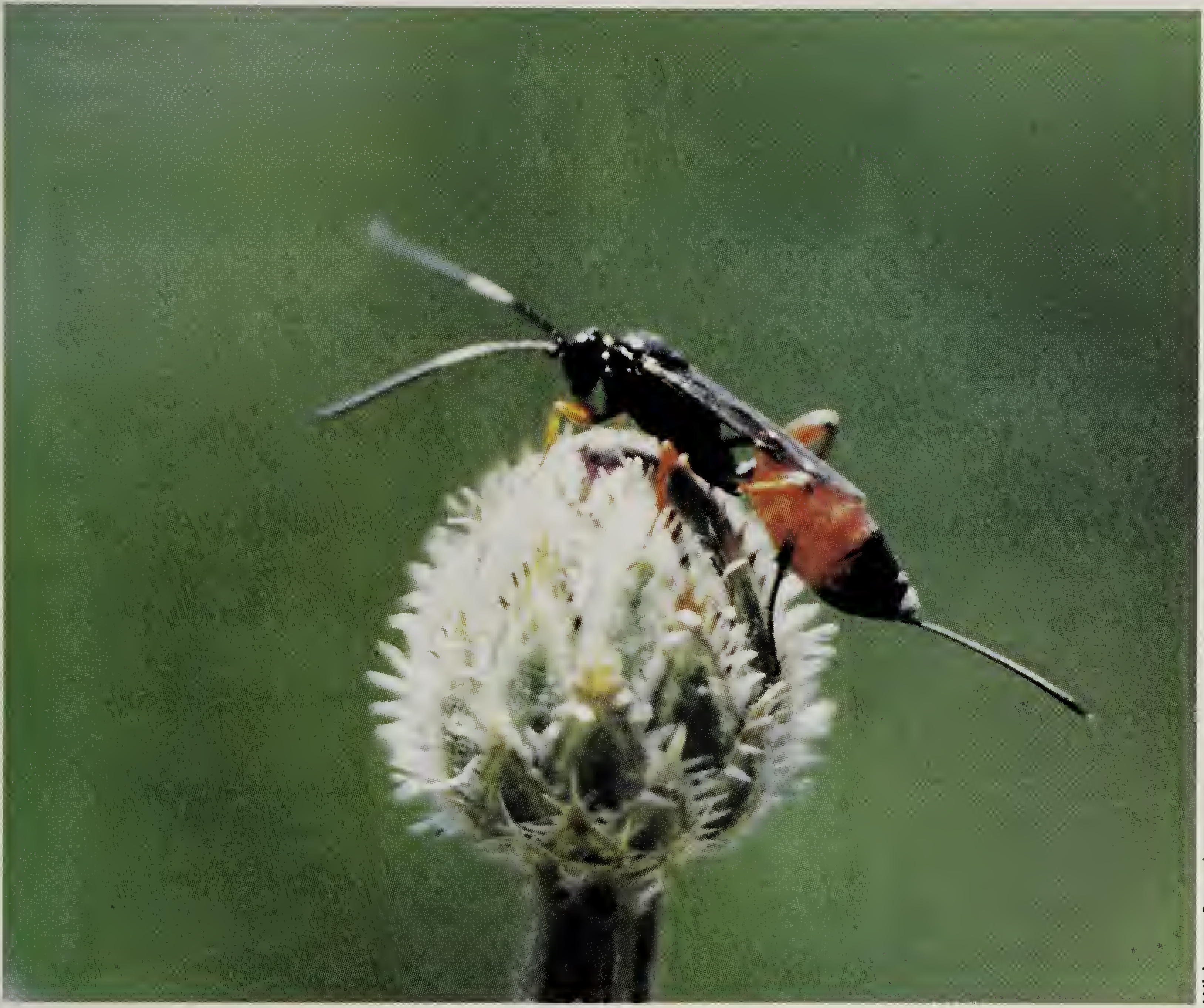
Amy Yarger, an insect enthusiast since childhood, received her M.S. from the University of Michigan studying plant-animal interactions. She has worked as a horticulturist at Denver Botanic Gardens since May 1996.

THE GOOD, THE BAD AND THE UGLY

by Whitney Cranshaw, PhD



Whitney Cranshaw

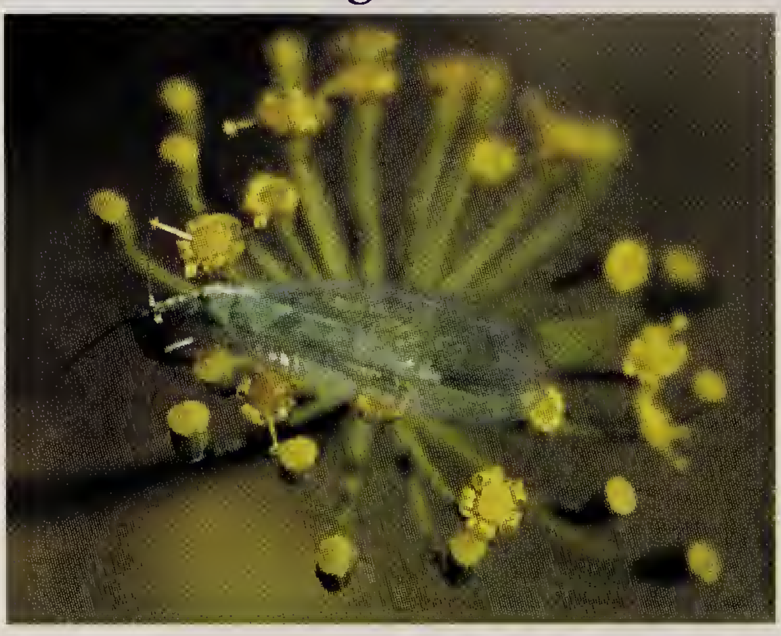
The parasitic wasp is a predator of very small insects including aphid and scale.

Compared with many areas of the country, problems with insect and mite pests in Colorado are fairly moderate. Although some insects may annually migrate into the state, freezing winter temperatures keep many insects from becoming permanently established. Unpredictable temperatures and strong winds can be as rough on the bugs as they may be to some plants. Also, in most yards there can be a healthy army of beneficial insects that feed on the undesirable pests, providing an important share of biological control.

However, there are a few garden pest insects that do succeed in rising to the top of the local gardener's "Most Unwanted" list. Some of these creatures that cause the greatest problems, and the beneficial insects that help manage them, are discussed in this article.

Wanted! The Good

Green lacewing


Whitney Cranshaw

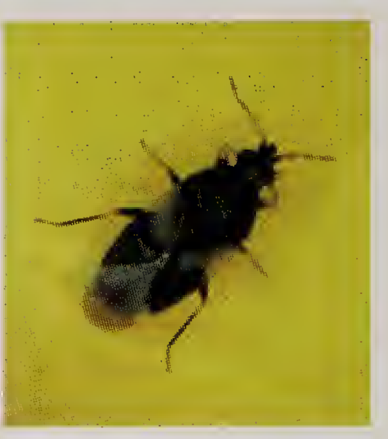
Description and habits Adult lacewings are attractive insects, pale green with large, clear, highly veined wings and bronze or golden eyes. Although some will feed on insects, most adult lacewings feed on nectar and pollen.

Lacewing larvae are voracious predators of insects and are sometimes known as "aphid lions." Pale brown in color and elongate in body form, their most distinctive feature is a pair of wicked-looking curved jaws that they use to capture prey. Lacewing larvae are general predators that feed on a wide variety of insects, including those larger than themselves.

Life history in Colorado While some lacewings winter as adults, and may enter homes for seasonal shelter, most winter within a small pill-shaped cocoon. They become active in late spring when the females lay distinctive, stalked eggs, approximately 1/2 inch in height, in small groups or singly on leaves of plants. The lacewing larvae emerge from the eggs in about a week and feed on small caterpillars and beetles as well as aphids and other insects. Several generations of lacewings are produced during the summer.

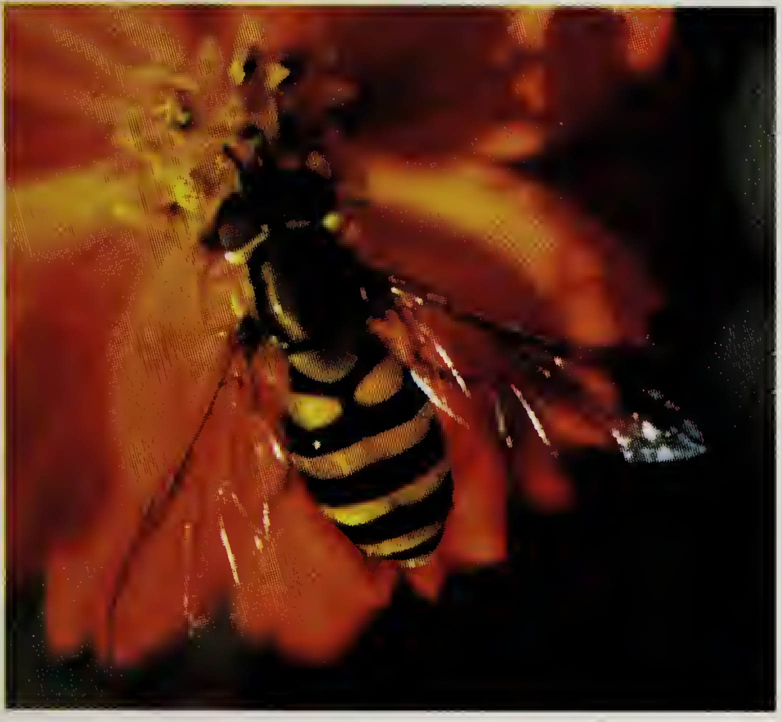
Minute pirate bug

Description and habits Minute pirate bugs are very small (less than 1/8 inch long) and adults are marked by black and white banding. The pale orange nymphs resemble hyperactive aphids, but they, as well as the adults, are predators. Common prey of minute pirate bugs are the smaller plant pests such as aphids, thrips, spider mites, as well as insect eggs.


Whitney Cranshaw

Life history in Colorado Adult minute pirate bugs emerge in spring and move to plants. Upon finding colonies of insects that could support their young, they begin to lay eggs by inserting them into plant tissues. One of the most common sites of activity is in and around flowers where thrips are present. In midsummer they may be more often seen cruising along leaves where they attack spider mite colonies. With the shortened days of fall, minute pirate bugs go dormant and seek out protected sites for winter.

Syrphid fly



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Description and habits Syrphid flies, also called flower flies or hover flies, are brightly-colored flies that closely mimic bees or wasps with their yellow/orange and black markings. Adult syrphid flies are harmless to humans and can often be seen feeding on flowers alongside bees.

It is the larval stage of the syrphid fly that is an insect predator — a specialist of aphids. Variously colored, the tapered maggots crawl over foliage and consume dozens of aphids daily. Syrphid flies are particularly important in controlling aphid infestations within curled leaves, sites inaccessible to the more bulky larvae of lady beetles and lacewings.

Life history in Colorado Syrphid flies emerge early in the season and the adults feed on nectar and pollen, essential for the development of their eggs. The females lay their small, oblong white eggs near colonies of aphids. Upon hatching, the larvae feed for about two to three weeks before pupating. Numerous generations may be produced during the season resulting in many syrphid flies present and feeding upon aphids at the end of the growing season.

Lady beetle

Whitney Cranshaw

Description and habits Lady beetles, also known as "ladybugs" or "ladybird beetles" are among the most familiar of the beneficial insects found in the garden. Typical adult lady beetles are brightly colored and boldly patterned. However, their larvae have a very different form, elongate and generally dark in color.

Some 80 species can be found in Colorado and their favorable reputation is well-deserved. Essentially all lady beetles are predators of other insects with a diverse diet that includes aphids, small caterpillars and insect eggs. The larvae are particularly predaceous and are capable of feeding on more than two hundred aphids a day.

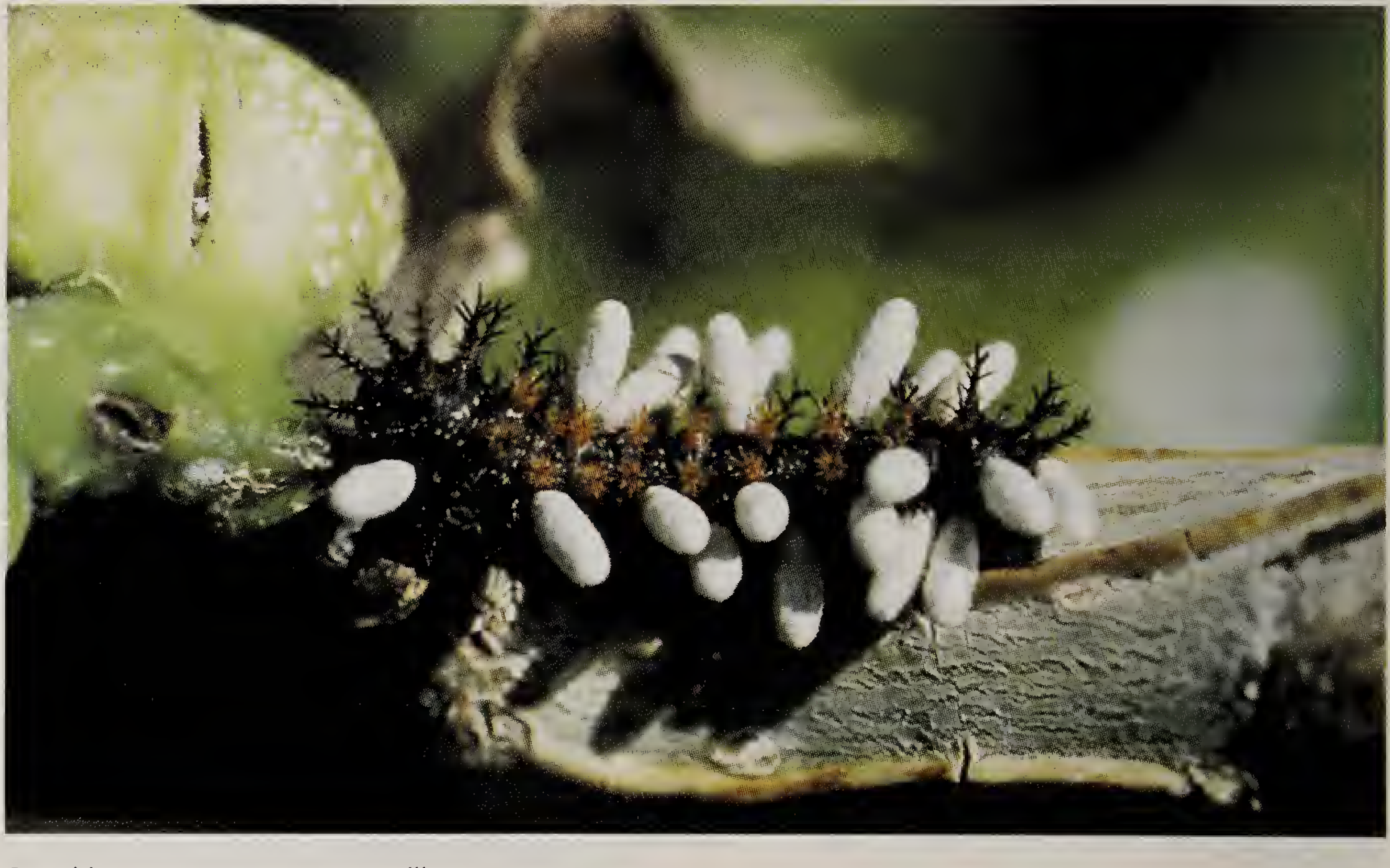
Life history in Colorado Most lady beetles winter as adults, hidden under fallen leaves, mulch or other sheltering debris. Some may also find their way behind building walls and one species, the convergent lady beetle, migrates to upper elevations during late summer.

During the growing season, adults lay masses of eggs near sources of prey for their young. The eggs hatch in about five days and the larvae immediately search for food. Following a two to three week period of intensive feeding, they pupate and transform to the adult stage. Two or three generations may be produced during the year before they scatter and enter winter dormancy.

When you purchase these beetles they are just coming out of their overwintering stage. Their natural inclination is to migrate before feeding and laying eggs. You can increase the chances of retaining them by purchasing beetles that have been given a special diet after collection to reduce migratory behavior. Beetles should be released at dawn or dusk, preferably just after watering.

Parasitic wasp

Description and habits Unlike other insect predators, the parasitic wasps develop within insects and are not free-living hunters when young. Instead, it is the adult female that seeks out the host insect and lays its egg in or on it. Scores of species of parasitic wasps are found in Colorado, each with their own habits. Some are very small and rarely observed, attacking small insects such as aphids and scales.



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Parasitic wasp cocoons on a caterpillar.

Others are even smaller, developing within the eggs of various pest insects. Larger parasitic wasps attack caterpillars, beetles and other insects.

There is usually little evidence of parasitic wasps in the garden because the young wasps develop inside the host insect from eggs that were inserted by the mother wasp. However, parasitized insects may be somewhat different in form. For example, aphids that are parasitized by these wasps are typically small and discolored and are called aphid mummies. Some braconid wasp species spin conspicuous yellow or white pupal cocoons after emerging from a host.

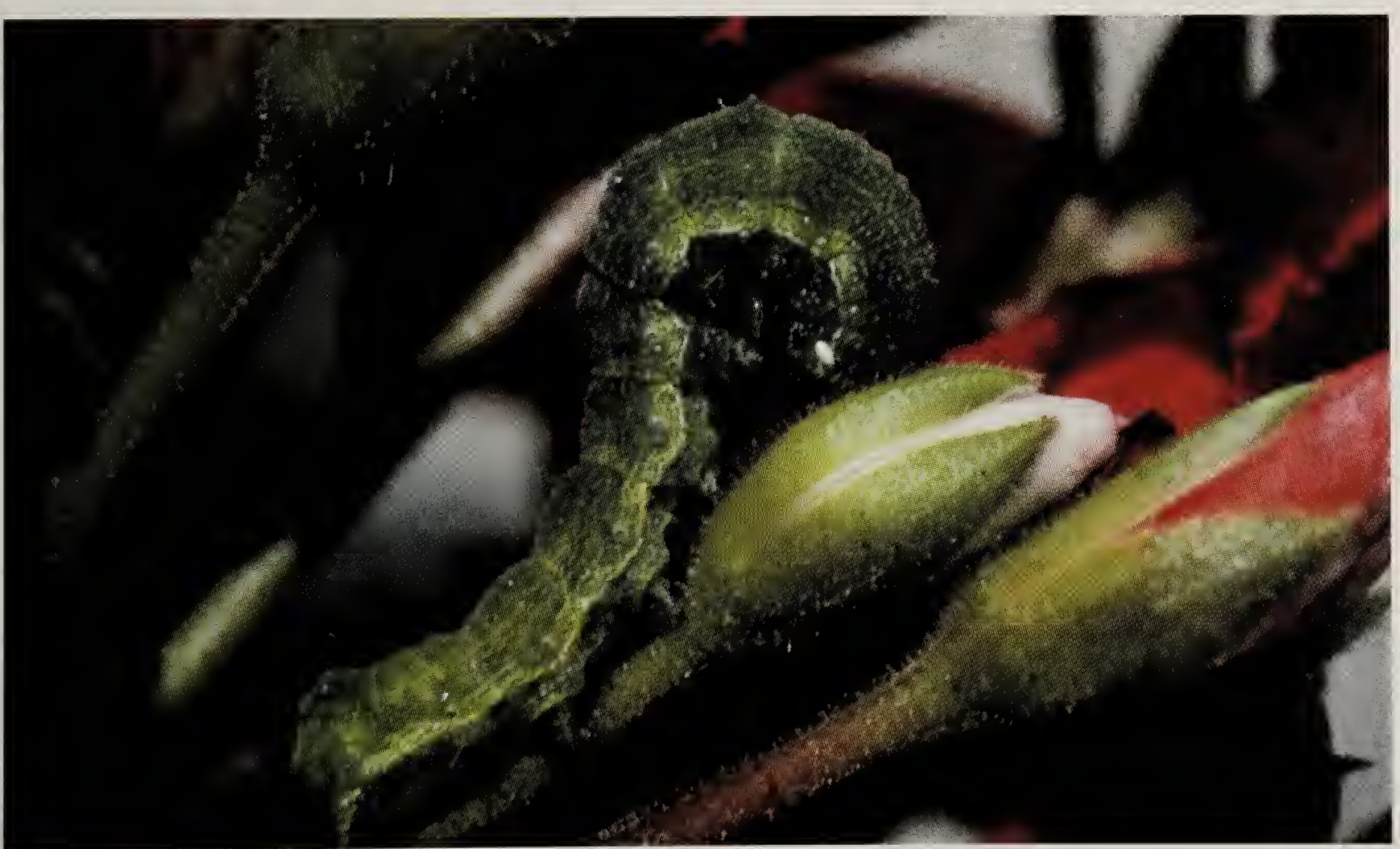
Life history in Colorado Most parasitic wasps winter as larvae or pupae within the host insect. Adults usually emerge synchronously with the stage of the insect that they attack. Therefore, the parasites of insects that have only a single generation a year, such as most scales, also have only a single generation. Parasites of aphids, on the other hand, may have several generations, each at two or three week intervals.

Unwanted! The "Bad"

Tobacco/Geranium budworm

Description and damage

Tobacco budworms (also known as geranium budworms) feed primarily on the buds and flowers of many garden plants, particularly geranium (*Pelargonium* cvs.), flowering tobacco (*Nicotiana* cvs.) and petunia (*Petunia* cvs.). The caterpillars mainly feed on the buds, preventing flower emergence. Petals of flowers that



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The tobacco budworm feeds mainly on buds, preventing flower emergence.

have matured may also be eaten, producing a ragged appearance. The caterpillars are highly variable in color, ranging from pale brown to a reddish-black, and are about one and one-half inches when full grown.

Life history in Colorado Tobacco budworms winter as pupae in the top few inches of soil. Soil temperatures below 20° F are lethal to the wintering insects. As a result, tobacco budworm problems tend to be inversely related to the severity of the previous winter. However, many budworms are protected by mulches and the radiant heat from soil warming by nearby buildings that help them to survive Colorado winters.

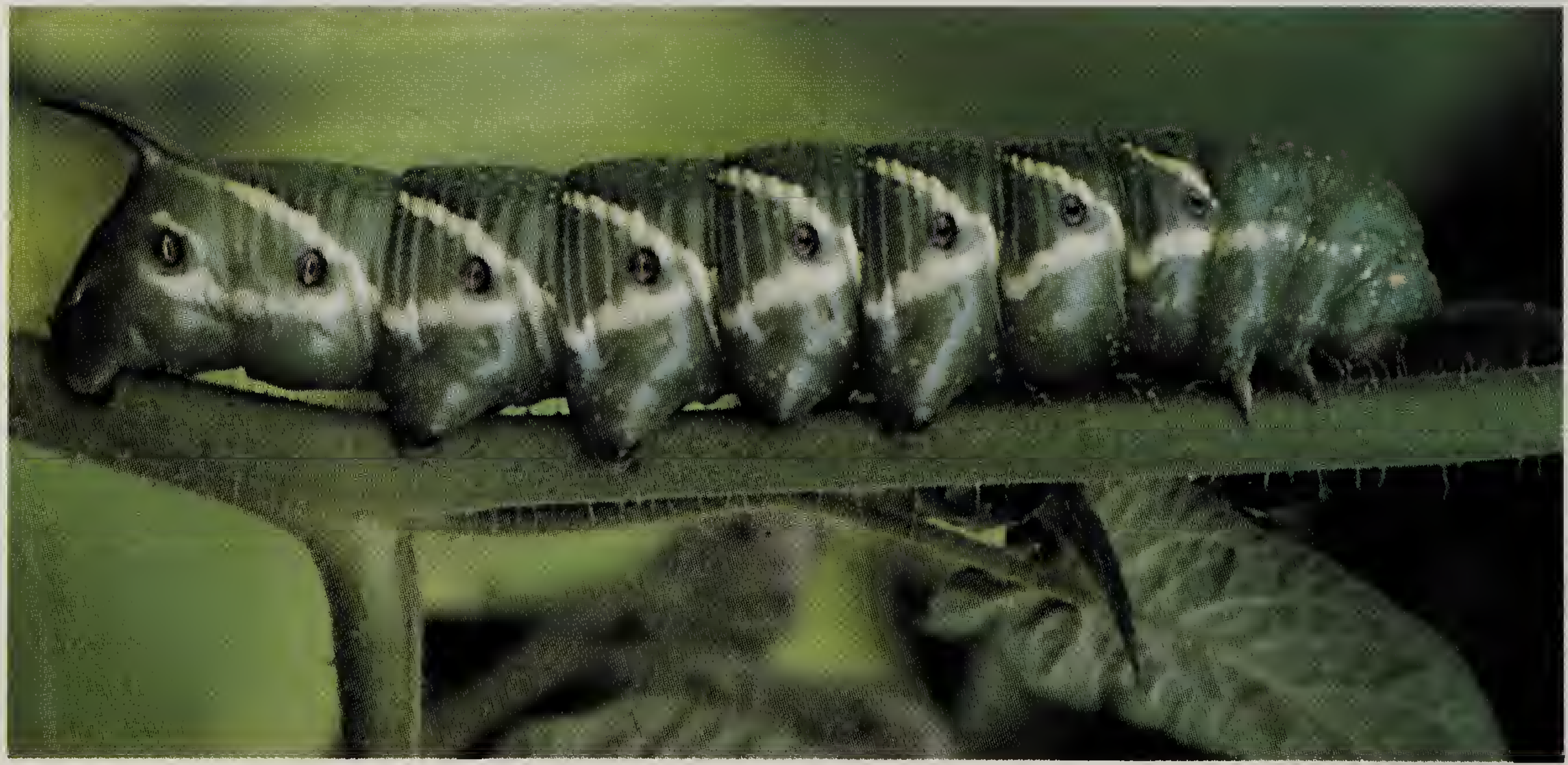
Typically there are two generations produced each season. The first group, which hatches in late spring and early summer, is often little noticed. Damage is more severe in mid- to late-summer with the second generation.

Management Larvae are most active shortly after dusk and may be hand-picked at that time. Recommended insecticides on geranium include permethrin and acephate; *Bacillus thuringiensis* (Bt), may be effective on petunia. Ivy geranium (*Pelargonium peltatum* cvs.) are largely resistant to budworm.

Tomato hornworm

Description and damage Hornworms, often reaching three to four inches in length, are usually the largest insects that one will ever encounter in a Rocky Mountain garden. They are endowed with a fearsome-looking (but utterly harmless) horn at the rear end of their body. They have a prodigious appetite, allowing them to rapidly defoliate plants and gouge ripening fruit.

Life history in Colorado Most tomato hornworms overwinter as a large pupa buried a few inches in



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The tomato hornworm is one of the largest insects to be found in the Rocky Mountain region.

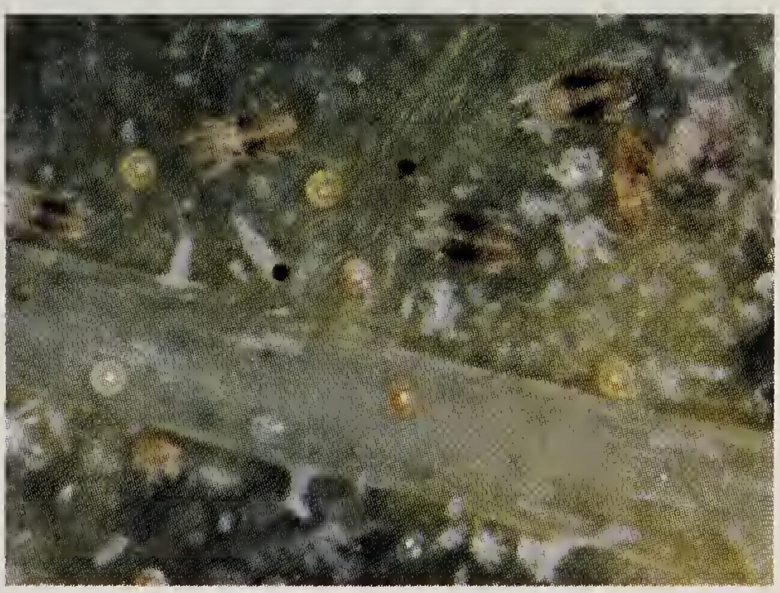
the soil. Adults, in their moth form, are most common in late spring or early summer and lay their eggs on tomato (*Lycopersicon esculentum*) during this time. After hatching, the caterpillars feed over a period of about three weeks. The majority of plant damage occurs in the last few days of this period.

Adult hornworms are known as sphinx, hawk, and more popularly, hummingbird moths. They are large, strong-flying moths that closely resemble hummingbirds in both flight and feeding habit. However, the hummingbird moths commonly observed in gardens are not the adult form of tomato hornworms. Usually they are one of the 20-odd non-damaging species that feed on trees or weeds as caterpillars and rarely attract attention.

Management Hornworms are readily controlled with Bt or sprays or dusts of insecticides containing carbaryl. They may also be hunted down and hand-picked off plants during plant inspections, which should be done every three to four days during the midsummer peak of activity.

Spider mite

Description and damage Spider mites are minute, somewhat oblong creatures that usually can be found on the underside of plant leaves. Their presence is first evident by the white flecking wounds they make on plant leaves. Symptoms of severe damage may progress to a general bronzing of foliage or premature defoliation along with webbing.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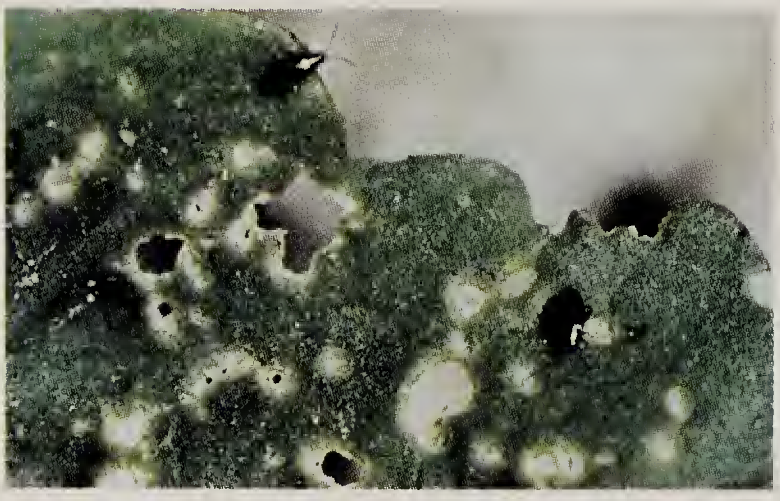
Life history in Colorado Most spider mites in Colorado overwinter as dormant adults on, or in the vicinity of, previously infested host plants. An exception are those that develop on evergreens and overwinter as eggs. During optimal conditions a generation can be completed within three weeks. Most spider mites thrive under hot, dry conditions. However, spider mites associated with turfgrass and conifers are most abundant in spring and fall.

Management Water management is key to spider mite control as dry conditions favor spider mite development and adversely impact their natural enemies such as minute pirate bugs and predatory mites. Numbers of mites may also be reduced by periodically hosing them with a strong jet of water. Pesticides effective against spider mites include horticultural oils, soaps and dicofol.

Flea beetle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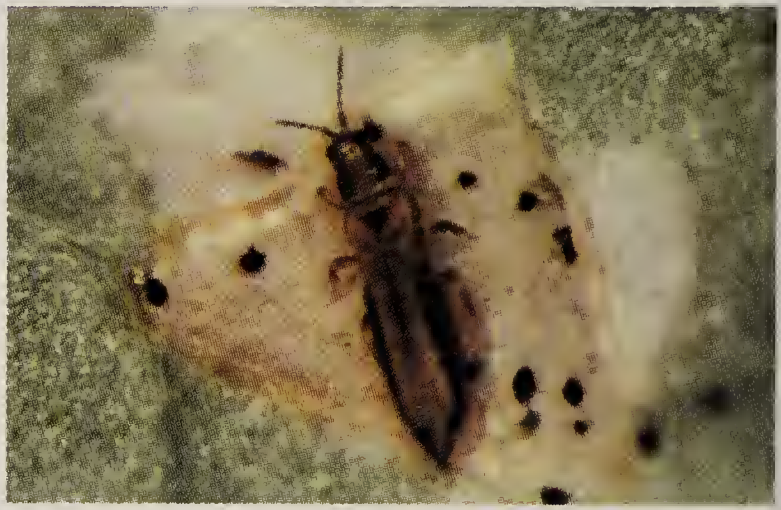
Description and damage Flea beetles are small humpbacked beetles that readily jump when disturbed. Adult flea beetles inflict their damage by chewing small "shothole" wounds in plants. Seedling plants, can be retarded in growth and even killed during severe infestations.

At least two dozen species of flea beetles exist in Colorado, each having a specific favored host plant. Most common is the western cabbage flea beetle that feeds primarily on radish *(Raphanus sativus* cvs.), broccoli (*Brassica oleracea* cvs.) and related plants. Potato flea beetles are common on tomato *(Lycopersicon esculentum)* and potato (*Solanum tuberosum*).

Life history in Colorado Flea beetles winter as adults in the general vicinity of previously infested plants. They are active during warm days in spring and may fly long distances to newly emerging plants. Adults feed on the leaves and later, lay eggs in the soil. Larvae feed on roots, but cause little injury. Often, a second generation is produced.

Management Seeding at an excessively high rate or purposefully seeding an attractive trap crop, such as radishes among broccoli, can divert many of the insects away from the main crop. Once established, plants usually outgrow injuries. Carbaryl, permethrin and diatomaceous earth are moderately effective at deterring flea beetle injury.

Thrip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Description and damage Thrips are minute, rivaling the spider mites as the "wee little creatures" of the garden. Less than 1/16 inch long, with a distinctive elongate body form, they feed on leaves and developing flowers, creating scarring wounds and deformities.

Life history in Colorado Most thrips that damage garden plants in the Rocky Mountain region overwinter as adults. Some, most notably the gladiolus thrip, winters within leaf and stem folds and other protective sites of the host plant. During the growing season, eggs are laid within plant tissues and the nymphs that subsequently emerge produce most of the feeding injuries. Several generations can be produced within the growing season. Each reproductive cycle can be completed within about three to four weeks.

Management Thrips are difficult to manage since they are so mobile and abundant. Gladiolus thrip, which overwinters in corms, can be killed prior to planting by submerging the corms in 120° F water for 20 minutes. Overhead irrigation and/or spraying with a hose will wash many thrips off plants. Acephate and permethrin have some effectiveness against thrips.

Tomato/Potato psyllid

Description and damage The tomato/potato psyllid is a small, aphid-sized insect that can produce unusual injury to potatoes and tomatoes. The saliva injected during feeding has systemic effects on these plants causing a wide range of disorders including discoloration and stunting of the foliage. Infested potatoes yield poorly and tubers may show defects such as premature sprouting. Tomatoes from psyllid-infested plants tend to be smaller and have a mealy texture.

Life history in Colorado The tomato/potato psyllid cannot survive Colorado winters. Annual migrations from southern Texas and Mexico move into the region, usually around mid-June. Usually two generations are produced during the season. Late-season populations are heaviest on tomatoes.

Management Damage caused by psyllids varies widely from season to season. The best way to detect problems is to look for the scale-like nymphs on the underside of leaves or their excrement on a plant's fruit. The latter is a unique material often called "psyllid sugar" that resembles salt or granulated sugar. Sulfur dusts, permethrin or diazinon are among the more effective controls.

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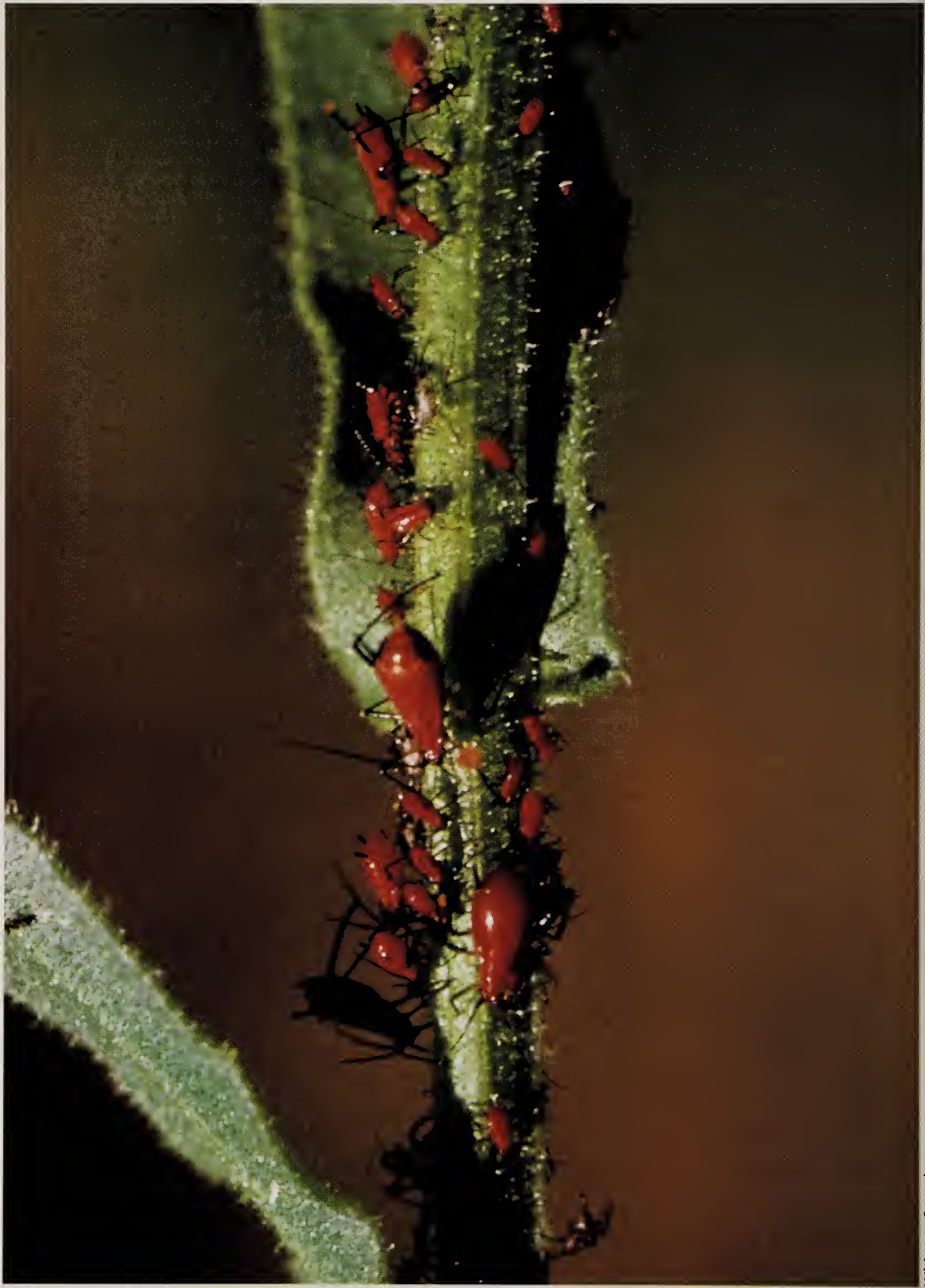


The damage inflicted by sap-sucking aphids can easily be identified by curled leaves and a trail of sticky honeydew.

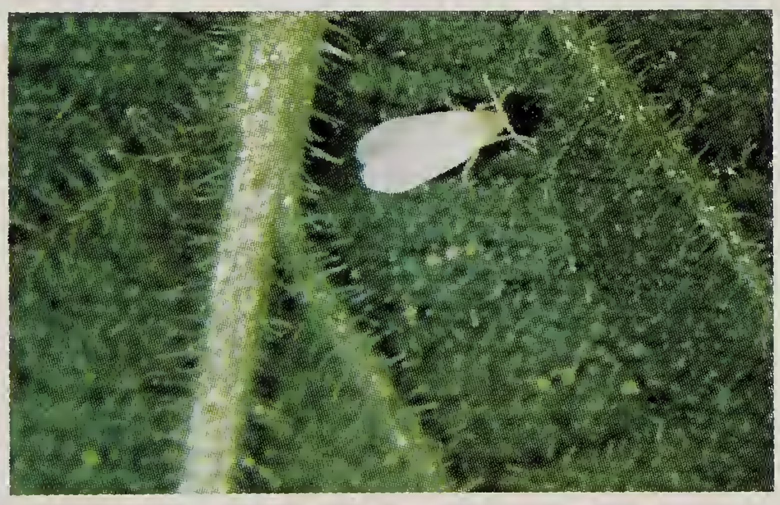
Aphid

Description and damage Aphids, probably the most common insects found on garden plants, can damage plants in many ways. All suck sap, but this usually is a minor plant health concern unless very high populations are sustained. The end product of their feeding, known as honeydew, is often of greater consequence. (Honeydew is sticky, sweet and highly attractive to ants and wasps.) The damage caused by some aphids is notorious for curling leaves as they are expanding during spring.

Life history in Colorado Most aphids overwinter as eggs which are laid in the fall near buds or emergent shoots of perennial plants. Two generations can occur on the spring growth of these plants. After this stage, winged forms of the aphids disperse and move to different summer hosts which often include many garden plants. During the summer, aphids reproduce asexually and produce genetically identical daughters, fully capable of reproducing in as little as two weeks after birth. Most adult aphids are wingless, but winged forms are produced to colonize new host plants.

Management Aphids succumb to many natural enemies, such as lady beetles, lacewings, syrphid flies and parasitic wasps. Often these predators sufficiently control aphids. However, ants sometimes protect aphids for their sweet honeydew and in such cases, it may be useful to eliminate the ants so that the natural enemies of aphids are unhindered.

Masses of aphids on leaves or stems can be washed away with a sharp jet of water and most aphids can be controlled by insecticidal soaps. Aphids overwintering on perennial plants that cause spring leaf curling problems can be controlled with spring treatments of dormant oils, which smother the eggs. In situations where aphids have already begun to produce leaf curling, systemic insecticides (e.g., acephate) can be effective — but should only be used on ornamental plants.



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Greenhouse whitefly

Description and damage The greenhouse whitefly is a small insect, slightly smaller than an aphid when fully grown. Wings of the adult insects are covered with a fine white powder, leading to its common name of whitefly. The immature nymphs are flattened, translucent and are found on the undersides of leaves. Both adults and nymphs suck sap from plants stunting growth during heavy outbreaks. Some honeydew

Whitney Cranshaw

Earwigs are unnecessarily frightening to most who encounter them.

may be produced, but not in quantities similar to that of aphids. The greenhouse whitefly feeds on a wide variety of plants but has some favorites such as tomato, cucumber *(Cucumis sativus* cvs.*)*, aster (*Aster* spp. and cvs.*)*, hibiscus (*Hibiscus* spp. and cvs.*)* and poinsettia (*Euphorbia pulcherrima* cvs.*)*.

Life history in Colorado Greenhouse whitefly is a subtropical insect incapable of surviving outdoors where there are killing frosts. Garden problems in Colorado originate from infested plants maintained in homes or greenhouses during winter. Once established outdoors, a generation can be completed in about a month and each female may lay a couple of hundred eggs during her lifetime. Large populations of whiteflies are most often found late in the season, particularly if the summer is warm.

Management Prevention is the best means of managing greenhouse whitefly in gardens. Transplants should be carefully examined at purchase and again prior to planting and discarded if whiteflies are observed.

Once established in the garden, whiteflies are difficult to eliminate. Horticultural oils and insecticidal soaps are among the most effective treatments for the nymphs; pyrethrins and pyrethroid insecticides (e.g., permethrin) are among the better treatments for adults. Some adults may also be trapped by use of yellow sticky cards. Few natural enemies attack whiteflies in gardens but parasitic wasps can be very useful for managing them in greenhouses.

European earwig

Description and habits Earwigs are readily recognizable by their prominent pincers on the hind end. Although rather fearsome-looking, the rear pincers have little force and are used primarily during mating. However, earwigs can produce a moderate bite with their jaws.

Earwigs are general feeders and can damage soft plant parts such as flower petals. However, they also eat many insects (such as aphids) and insect eggs and can have a beneficial effect on the garden.

Earwig's most annoying characteristic is that they get into everything. This is related to their habit of seeking dark, tight and slightly moist places during the day. As a result they often show up "at the scene of a crime," such as at a codling moth hole in an apple or at a leaf curled by aphids. They likely did not produce the injury and may have actually eaten the culprit.

Life history in Colorado Earwigs overwinter in the adult stage becoming active during warm days in late winter. Nests are produced in small hollows dug underneath a rock or in some other protected site. The eggs are tended by the mother and typically hatch in mid-spring. The mother will continue to guard and care for the young earwigs for several weeks until they have molted and are ready to leave the nest. The young then forage on their own, becoming fully grown in about one month. A second brood may be produced in late spring.

Management The habit of earwigs to seek shelter during the day causes them to collect under boards, burlap, moistened newspapers or similar objects. They can easily be collected from these sites and destroyed or relocated. Insecticide baits for earwigs are available from some garden centers and nurseries. Sprays around the base of plants are also used for earwig control.

Plants that Promote a Healthy Garden Habitat

Insect predators must have enough food to allow for reproduction and development. This means there must always be some pest insects in the vicinity to maintain a population of their natural enemies. Biological controls have a rough time surviving and thriving in a garden where all pests are eliminated.

Adult lady beetles, lacewings, syrphid flies and parasitic wasps frequently feed on nectar as a source of sugar-rich energy and may use pollen as an important protein supplement. Therefore, it is important to provide flowers that are accessible to small insects, since their mouthparts cannot reach deeply into the flower. Shallow flowers such as alyssum (*Lobularia maritima* cvs.), dill (*Anethum graveolens*), certain mints (*Mentha* spp. and cvs.) and cilantro (*Coriandrum sativum*) are particularly good food plants for these beneficial insects. Numerous studies have shown that the availability of flowering plants that provide these supplementary foods can increase the beneficial activities of these natural enemies.

Avoid chemical and cultural control practices that damage biological predators. Insecticides vary widely in their ability to kill natural enemies of pest insects. Selective controls, such as horticultural oils or Bt, can leave these natural predators uninjured.

Food sources of beneficial insects:

Scientific Name	Common Name
Achillea filipendulina	fernleaf yarrow
Achillea millefolium	common yarrow
Ajuga reptans	carpet bugleweed
Allium tanguticum	lavender globe lily
Anethum graveolens	dill
Anthemis tinctoria	Dyers' chamomile
Aquilegia spp.	columbine
Astrantia major	masterwort
Aster alpinus	alpine aster
Aurinia saxatilis	basket of gold
Atriplex canescens	four-wing saltbush
Callirhoe involucrata	poppy mallow
Coriandrum sativum	coriander
Foeniculum vulgare	fennel
Lavandula angustifolia	English lavender
Limonium latifolium	wideleaf sea lavender
Lobelia erinus	edging lobelia
Lobularia maritima	sweet alyssum
Mentha x *piperita*	peppermint
Monarda fistulosa	wild bergamot
Penstemon strictus	Rky. Mtn. penstemon
Potentilla recta 'Warrenii'	Warren's cinquefoil
Potentilla crantzii	alpine cinquefoil
Sedum album	white stonecrop
Sedum kamtschaticum	orange stonecrop
Sedum spurium	showy sedum
Solidago virgaurea	European goldenrod
Stachys officinalis	wood betony
Tanacetum parthenium	feverfew
Veronica spicata	spike speedwell

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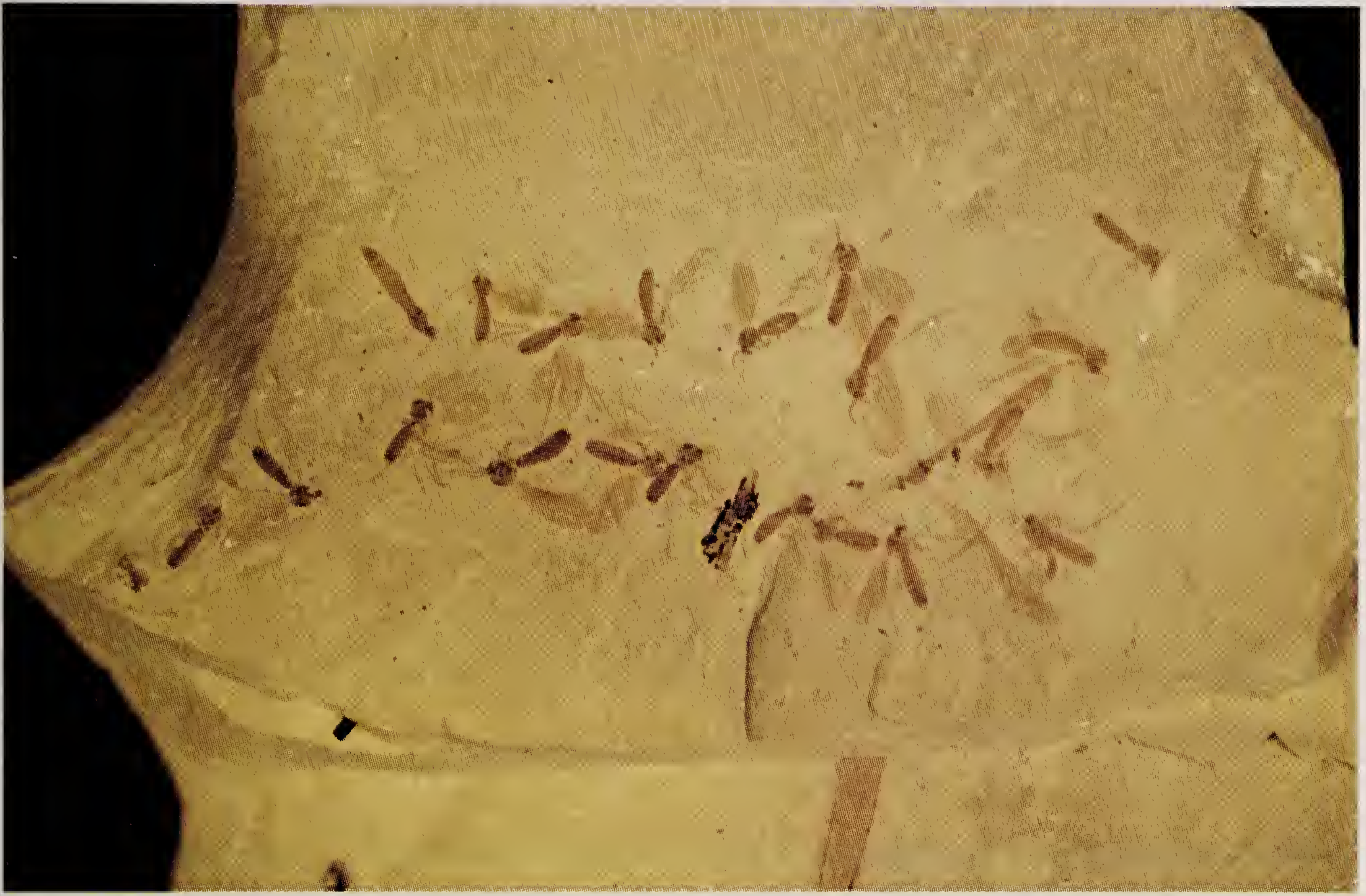
Whitney Cranshaw, PhD, has been a professor and Cooperative Extension specialist at Colorado State University since 1983. His responsibilities involve development of insect management methods for pest insects and mites affecting horticultural crops in Colorado. Dr. Cranshaw is a frequent speaker and often writes for national and regional publications. He has also authored two books, *Pests of the West* and *Bagging Big Bugs*.

THE BIG WORLD OF SMALL CREATURES

by Paula E. Cushing, PhD


Kirk Johnson, Denver Museum of Natural History

These forty-five-million year old Plecia *fly and crane fly Tipulidae fossils are evidence of the long history of insects.*

Insects, spiders and other hard-bodied creatures with flexible, jointed legs are all in the phylum Arthropoda. Fossil-bearing rocks containing arthropods date back to the Cambrian Period, 550 million years ago. This group of animals is the most extraordinarily successful group of living organisms on earth, surpassing all other major groups in numbers of species and adaptability. At least one million species of arthropods have thus far been described, comprising at least 85 percent of all described animal species and over 50 percent of all living organisms. They can be found in essentially every environment on earth. Spiders have even been collected on the high slopes of Mount Everest.

Insects, spiders, centipedes, millipedes, crabs and all other arthropods share certain characteristics. They all have segmented bodies. Arthropods are thought to have evolved from a worm-like ancestral group, since, like worms, their bodies are divided into different segments. However, in worms each segment of the body is basically a repetition of every other segment. In arthropods the body segments have become fused into spe-

Whitney Cranshaw

The centipede is thought to have evolved from a worm-like ancestral group.

cialized regions, such as the head, thorax and abdomen of insects.

Insects and spiders create a distinct "ick" feeling in many people due largely to their ability to move rapidly across our paths with multiple pairs of legs, often seeming to appear from nowhere and disappear just as rapidly. Arthropod's legs are divided into segments, connected by membranous joints which afford them great flexibility of movement.

Arthropods are also characterized by a hard outer or exoskeleton composed largely of a complex polysaccharide called chitin. Proteins and fats are also embedded in this chitinous exoskeleton, making it a good protective covering that is fairly impermeable to water. The hardness of the exoskeleton is due to the fact that it is scleritized or tanned, meaning that proteins have combined with molecules called quinones to make the covering stiff and hard. Having a skeleton on the outside, instead of the inside, means that arthropods must periodically molt, or shed, their skeletons in order to grow.

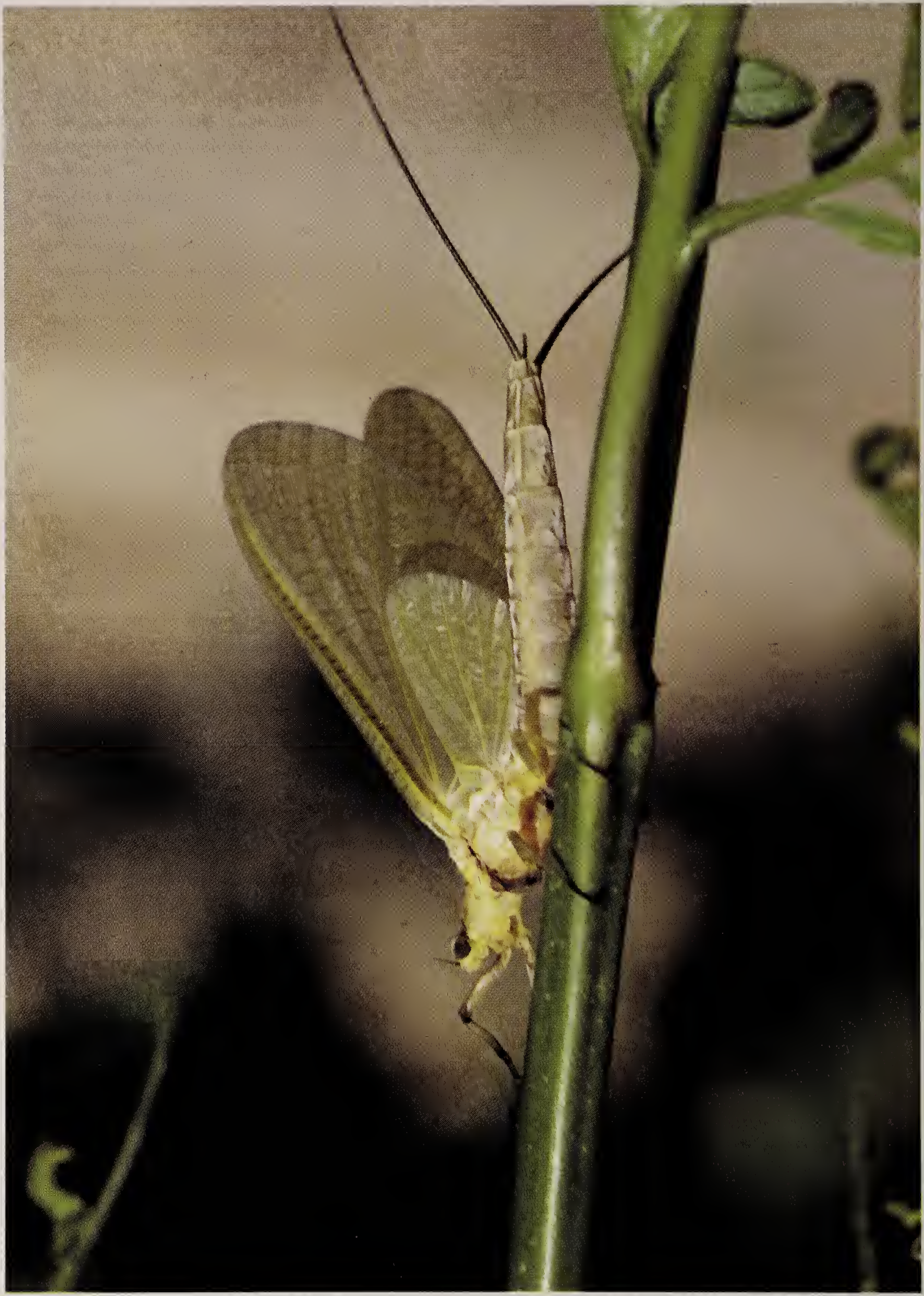
Finally, all arthropods have a specialized nervous system made up of a dorsal brain, a ventral nerve cord, and clusters of nerve tissue called ganglia in each major region of the body. Damage to one of these multiple nerve centers in an arthropod does not necessarily affect the function of the other nerve centers. If you thought the movements of a headless chicken were unnerving, you should watch a headless ant going about its business as if all were right with the world. An insect that has lost its head can still live for quite some time until finally succumbing from starvation or desiccation. A male praying mantis is often eaten by the female while he is mating with her. The male can complete copulation quite normally even *sans* his head. New Guinean headhunters used praying mantis as icons because of the ability of males to continue functioning even after losing their heads at critical moments!

Like their present-day relatives, extinct arthropods that lived in the Cambrian seas had segmented bodies, jointed legs, chitinous exoskeletons and, probably, multiple ganglionic nerve centers. In this environment, these adaptations made the animals both effective predators and effective escape artists. The hard exoskeleton protected them from the bites of predatory fish and the jointed, flexible appendages and segmented bodies made them good swimmers and movers through their watery environment. As the seas became more crowded and the tectonic plates of the earth's surface collided creating more and bigger land masses rising out of the seas, organisms began moving into this new terrestrial environment. Greater predation pressures, competition in the Cambrian seas and the wide-open niches on land probably triggered this movement. Among the first organisms to make this transition from an aquatic to a terrestrial habitat were the arthropods.

This transition was likely less dangerous for arthropods than for other organisms since the hard exoskeleton, perhaps already studded with fats and proteins, afforded them considerable protection from desiccation in the dry terrestrial environment than did the permeable skin of ancient fish, for example. The jointed appendages allowed arthropods mobility in an aquatic or a terrestrial environment. In a sense, arthropods were preadapted to the harsh, dry conditions in this dramatically new environment. Because of this, they have been exceptionally successful invaders and colonizers of every possible niche on earth.

By far, the most successful arthropods are the insects, with more than 700,000 described species. This number includes only those species known to science; yet many more species are still undiscovered, especially in the tropics. Estimates of the number of insect species range from three to thirty million.

The success of insects is due to many factors, including their small size. Small organisms can fit into a greater variety of habitats than larger organisms. Insects were also the first group of organisms to take to the air, preceding reptiles, birds and mammals. Some researchers hypothesize that insect wings evolved from lobe-like appendages that served as gills on the ancestral arthropods living in



The mayfly inhabits completely different environments during each stage of its life cycle.

the sea. Terrestrial insects had no use for external gills which would quickly dry out, but wings enabled them to escape predators and to disperse to new, uncrowded habitats.

Many insects undergo a developmental process known as complete metamorphosis in which the immature life stages look completely different than the adults. They eat different foods, and, in some cases, are even found in different habitats. Such a pattern enables these insects to utilize completely different resources at different life stages. For example, dragonfly, caddisfly, mayfly and others live in an aquatic habitat as larvae where they can thrive on the abundant food and nutrients found there.

The winged adults can take advantage of the resources offered by their terrestrial habitat, including more efficient means of dispersal and locating mates. Even insects such as butterflies and moths, whose larvae and adults are both terrestrial, can utilize different resources; caterpillars feed on the leaves of plants while the adults feed on pollen or nectar.

The oldest fossil insect dates back to the Devonian Period of the Paleozoic Era about 380 million years ago. This fossil insect is a collembolan or springtail, a small soil-dwelling insect found only in moist environments such as under logs or in the soil. Primitive wingless insects such as these were probably the first to colonize land.

The first insects with well developed wings, including giant ancestors of present-day dragonflies with wingspans of up to 70 centimeters (27.5 inches), showed up on the scene during the Carboniferous Period about 300 million years ago. Other ancient groups whose fossils date back hundreds of millions of years include the mayflies and the cockroaches. Some of these early insect groups fed on rotting organic matter and were not very particular about what they ate. Others, such as the dragonflies, were predators. But some, such as the early orthopterans (related to present-day grasshoppers and crickets), relied on plants for their food. These early plant feeders probably fed on ferns.

Later, during the Permian Period, 280-230 million years ago, gymnosperms such as pine and fir trees, became dominant among the flora. At this time, there was a dramatic increase in insect diversity concurrent with this increase in plant diversity. At this time, the first stoneflies, thrips, beetles and true flies appear in the fossil record.

The dominance of insects really occurred when flowering plants underwent an explosion of species during the Cretaceous Period. When flowering plants, rather than gymnosperms, became dominant, insects such as butterflies and moths really took off (so to speak) on their own evolutionary divergence. At least two-thirds of all flowering plants rely upon insects for their reproductive

Whitney Cranshaw

The ant exemplifies the segmented body typical of insects.

success. Many bees, wasps, butterflies, moths and flies have evolved a co-evolutionary dependence on flowering plants. Without the pollinating services of insects, many plant species, including those that humans rely upon for food, would go extinct.

Insects and other arthropods play many crucial ecological roles. Besides serving as pollinators, arthropods are also important scavengers that break down organic matter. Some are predators and parasites of other arthropod populations, and, some are most familiar as "pests." However, insects are only considered pests when they negatively impact human activities. The number of beneficial species of arthropods far outnumbers the pest species.

Arthropods are an integral component of any ecosystem whether it is defined by garden walls or by agricultural fields surrounding a forest plot. At the base of the food chain within any ecosystem are the plants. Many groups of insects rely directly on plants for their food. For example, stick insects, butterflies, moths and grasshoppers are strict herbivores. Many hymenopterans (bees, wasps, ants and the like) as well as many beetles are also herbivores. Other arthropods rely on plants indirectly as predators or parasites of the herbivores. The top predators in most ecosystems on earth are not

continued on page 58

Whitney Cranshaw

Without spiders, humans would be up to their eyeballs in insects.

Insect Wonders
James K. Wangberg

The insect world is truly a wondrous place with a diversity of species unmatched in the animal and plant kingdoms. Such diversity translates into amazing form and function that give credence to the cliché that fact is often stranger than fiction.

Some of these amazing facts and insect wonders are revealed in the answers to questions that children ask adults. The following are some excerpts from the book *Do Bees Sneeze? And Other Questions Kids Ask About Insects*, James K. Wangberg, Fulcrum Publishing.

Michael Weissmann

The bee is an insect with warning colors.

Why are bees black and yellow?
Many bees and wasps are black and yellow to warn others that they can sting. These insects have what are called warning colors so other animals will quickly learn to leave them alone. It's like nature's stop sign. The natural enemies of insects have learned to recognize red and black, orange and black, and yellow and black as signs of danger.

What is the smallest bug in the world and how small is it?
The fairyflies, which are not really flies, but actually tiny wasps, are among the smallest of all known insects. The adult fairyfly may be less than one millimeter (smaller than a 16th of an inch) in length. They are so small that they can live inside other insects' eggs! They are insect egg parasites and feed within their host's eggs.

Can spiders fly?
There is no such thing as a spider with wings, but believe it or not, spiders can be seen flying through the air, sometimes thousands of feet above the ground! How do they do it? They use their silk like a hot air balloon. They can fly through the air by letting out a long trail of silken web that gets caught in the wind and blows the spider to new places. This is called ballooning and is how many young spiders find new homes.

Do insects snore?
Insects do not snore because they do not breathe through their mouth or have a nose like we do. Therefore, they can't make the snoring sounds that some people and animals make while sleeping. There are other sounds insects can make with air entering and exiting their bodies, but snoring is not one of them.

Why do bees make honey?
Honeybees make and store honey in their honeycombs for a winter food supply. They usually get plenty of sugar and protein from the nectar and pollen that flowers provide in the spring and summer. They also use the flower's nectar to make their honey, so when the flowers and nectar are gone there will be enough honey in storage to get them through the winter.

James Wangberg

Some caterpillars create a tent for their permanent home.

Do insects have permanent homes?
Some do and some do not. The social insects, which live in colonies, often make their nests or homes in permanent sites. An ant, bee, wasp or termite nest may be in the same spot for many years, until food shortage, disease or a major disturbance drives them away or kills off the colony. Groups of tent caterpillars build large silken tents as resting sites and shelters from enemies and the weather. They are permanent homes for the caterpillar until they change into a moth.

There are also some insects, called gall insects, that have permanent homes made for them by plants. Tiny gall wasps, gall midges and other gall-forming insects lay eggs in plant buds, leaves and other plant parts. The eggs hatch and the young gall insects feed on the plant, but while this is happening, the plant grows a gall, which is a special protective structure that surrounds the insect, giving it shelter for its entire feeding stage.

What is the largest bug?
Among the largest insects in the world are the goliath beetles of Africa which are nearly 100 millimeters or four inches in length. They are very heavy bodied and about the size of a man's fist!

AUTHOR BIOGRAPHY

James K. Wangberg is a Professor of Entomology and Associate Dean and Director of Academic and Student Programs in the College of Agriculture at the University of Wyoming in Laramie.

Beetles and other arthropod scavengers play an important role in the environment as decomposers of plant material.

Whitney Cranshaw

lions, tigers and bears, but are, in fact, spiders. It has been estimated that one acre can support more than two million spiders. Without spiders and the insects that feed on or parasitize other arthropods, humans would be up to their eyeballs in insects.

Arthropods, particularly such insects as cockroaches, termites, springtails, bark or book lice and some beetles also serve an important role as detritovores or scavengers, breaking down dead plant material. Other scavengers, such as certain beetles and flies, also break down dead animal material. Without these arthropod scavengers and detritovores, fungi and soil bacteria could not as efficiently decompose organic matter to release the nutrients back into the environment.

Humans share the planet with more species of arthropods than any other phylum. Arthropods are an essential component of all nutrient cycles and of food webs in nearly every ecosystem on earth. The communities of organisms that comprise every ecosystem are composed largely of arthropods and are largely responsible for maintaining the healthy functioning of our planet.

AUTHOR BIOGRAPHY

Paula E. Cushing, PhD, is the Curator of Entomology and Arachnology at the Denver Museum of Natural History. She is an arachnid, or spider, specialist and conducted a 1999 Colorado Spider Survey to document the species diversity and species distribution in Colorado. Dr. Cushing earned her PhD from the University of Florida and has taught general biology, ecology and invertebrate zoology at the University of Florida and the College of Wooster in Ohio.

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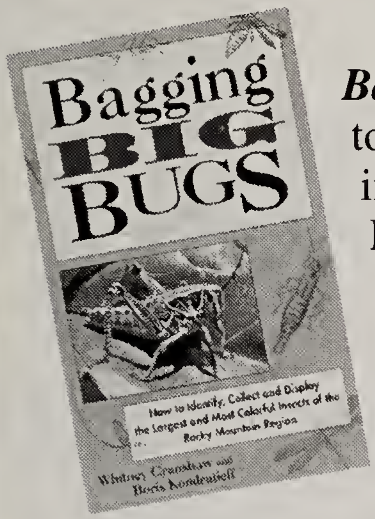
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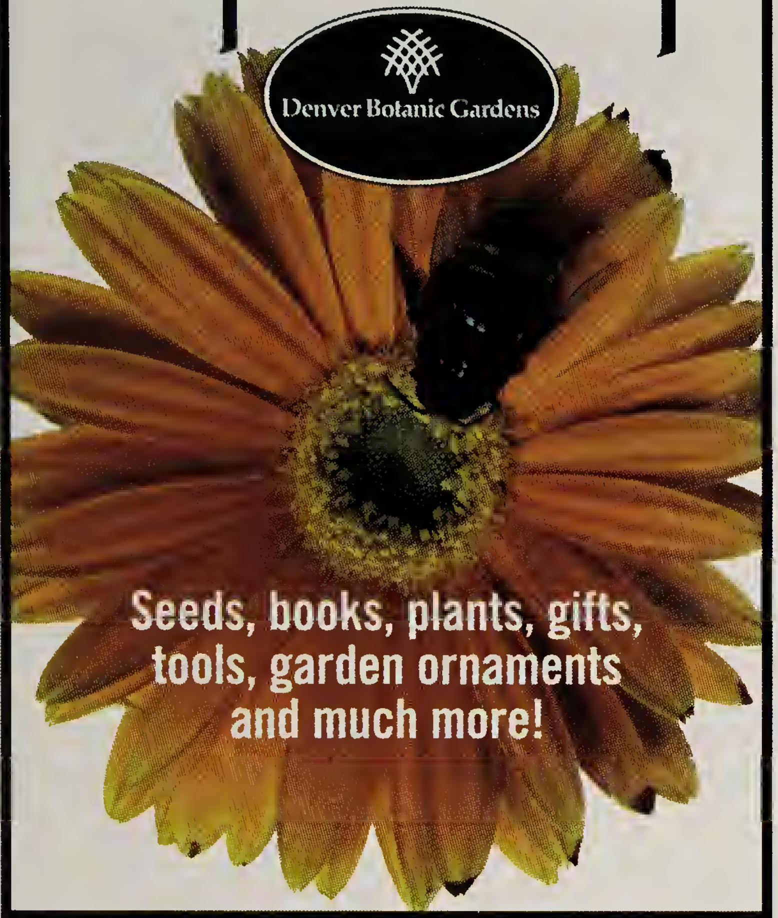
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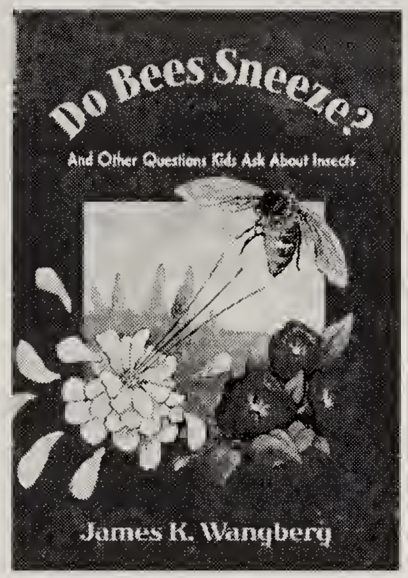
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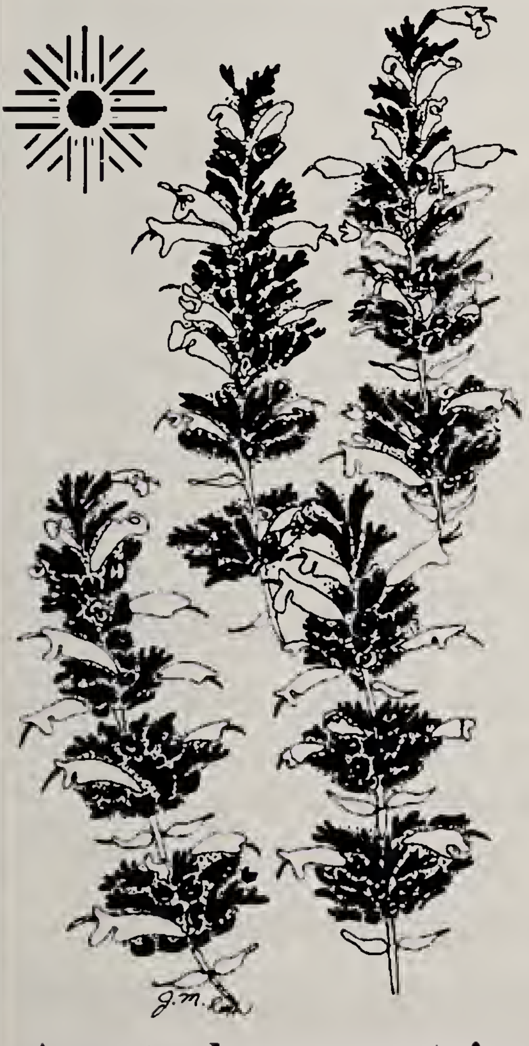

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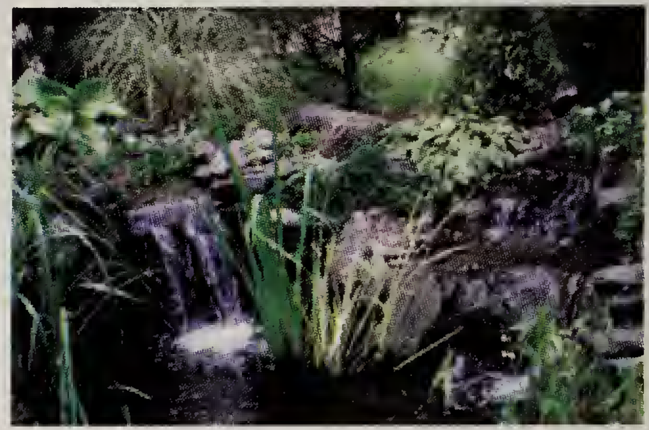

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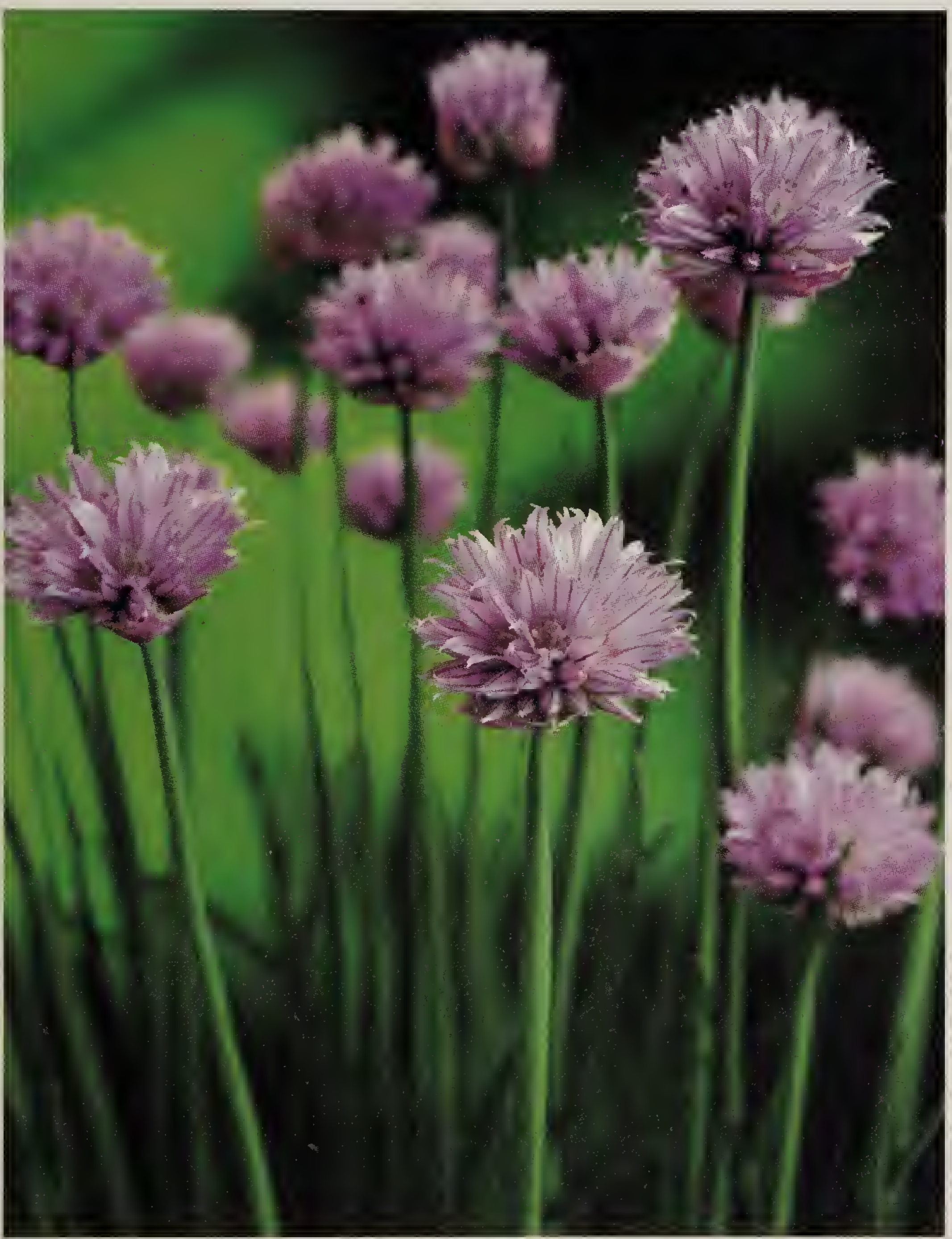

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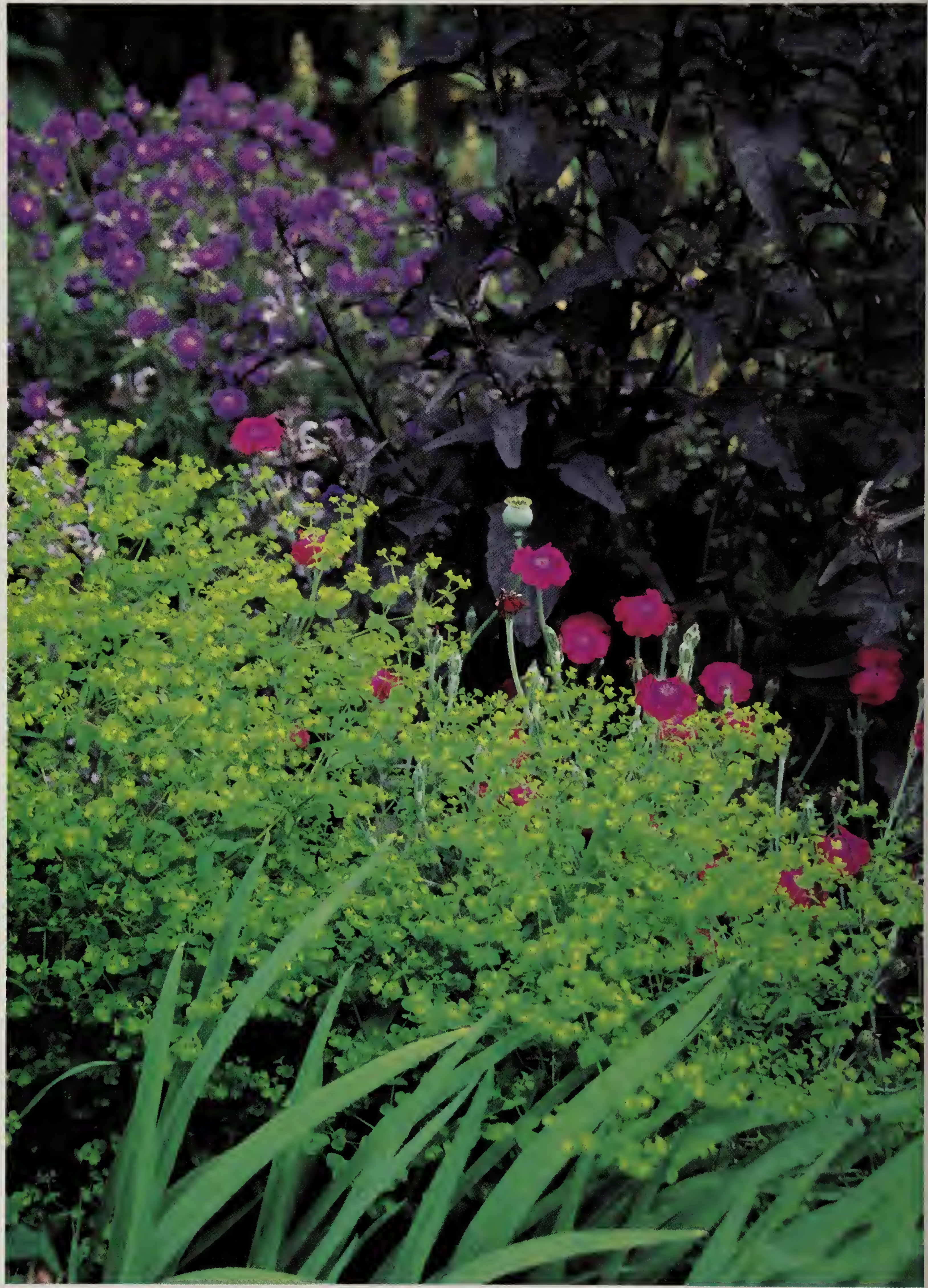

A skirt of lady's mantle surrounds brilliant rose campion and bronze-leaf perilla.

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Front/back cover photos: Garlic chives (*Allium tuberosum)/* English chamomile tea (*Chamaemelum nobile*) by Joe Coca
Inside covers: Thyme (*Thymus* sp.) by Jim Havey

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Joe Coca

Cilantro adds a bold, unique flavor to salsas and sauces.

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by Debbie Whittaker

A gardener's bounty

A dizzying array of fresh herbs is available to those who grow their own. The vast majority of herbs is commercially unavailable, but in an edible landscape, the choice is seemingly endless. Hardy perennials like chocolate mint (*Mentha* × *piperita* 'Chocolate'), lemon thyme (*Thymus* × *citriodorus*) and garden sorrel (*Rumex acetosa*) provide beauty throughout a long growing season during which they can be pruned and tipped regularly for use in the kitchen. Deep purple basil (*Ocimum basilicum* 'Purpurascens') and red shiso (*Perilla frutescens*) make a dramatic statement planted among annual herbs like arugula (*Eruca sativa*), cress (*Lepidium sativum*) and other greens. Their fleshy leaves spread out to blanket the space after the greens are picked, or to mask the unattractive stumps of cut-and-come-again lettuce (*Lactuca sativa*) while it regenerates. Fabulous flower beds can consist solely of edible flowers.

Although innovative cooks often enjoy growing unusual herbs, cultivating plenty of common herbs like parsley (*Petroselinum crispum*), chives (*Allium schoenoprasum*) and sage (*Salvia officinalis*) has some advantages. Abundance, ease, expense and aesthetics speak for themselves. There are few things as satisfying as having so much basil that you have to make pesto; or running out your back door to snip the final touches for your dinner; or feeling smug as you walk past those expensive, little packets of herbs in the grocery store.

Joe Coca

Parsley is an easy-to-grow, productive herb.

Many herbs have a rampant ability to thrive. Mints (*Mentha* spp.) are notorious; borage (*Borago officinalis*) reseeds like mad; and sweet violets (*Viola odorata*) spread so rapidly that many people use them only for ground cover. Yet, once they find their way to the kitchen, such herbs are held in high regard. Only gardeners can easily access the many varieties of mint that proffer the subtle undertones of pineapple, orange or basil in grilled vegetables, meats and cooked grains. Borage is one of the most beautiful and delicious of the edible flowers, with a mild, cucumber flavor. It can be used to garnish most savory dishes, and its delicate flower makes a stunning presentation. Most people eat only the flowers of the common sweet violet, but the young leaves are a fine addition to salads, and the older leaves can be used as a pot herb. Culinary herbs are rich in vitamins and minerals. Sweet violet is no exception, being referred to by naturalist Euell Gibbons as "nature's vitamin pill."

Fresh, leafy herbs: Snip and tuck

Fleshy, leafy herbs are fast, easy and versatile to use. Tender, delicately-flavored herbs like basil, dill (*Anethum graveolens*) and cilantro (*Coriandrum sativum*) can be snipped over, mixed into and tucked under anything you prepare, cooked or raw. The beauty of this method is that you can test before you add it to the entire dish, so you can be creative and determine amounts to taste. Some people relish the aromatic headiness of a predominant herb flavor. Others prefer subtle undertones.

Debbie Whittaker

French tarragon is delicious when snipped fresh over a variety of foods.

Be brave. Snip some French tarragon (*Artemisia dracunculus* var. *sativa*) over roasted beets. Serve grilled salmon over a bed of sorrel. Mix fresh lemon balm (*Melissa officinalis*) into cooked rice. Fresh, leafy herbs are a wonderful addition to a wide range of condiments. Stir a couple of tablespoons of snipped herb into softened butter, mayonnaise, mustard, cream cheese or drained nonfat yogurt.

Cooking with fresh herbs

Adding a few tablespoons of fresh herbs instantly transforms ordinary foods into gourmet fare. Fresh herbs are forgiving, which is not often the case with dried forms. The standard when substituting fresh herbs for dried is to use three times more fresh herb, but taste can vary considerably. The fresh leaves of delicate, fleshy herbs like basil and chives are heat-sensitive and tend to dissipate during cooking, so these herbs are best added after food has been removed from the stove.

Woody herbs: Best for cooking

Soups, stews, stir-fries and slow-cooked sauces are significantly enhanced with the addition of small amounts of strong, woody herbs like rosemary (*Rosmarinus officinalis*), oregano (*Origanum vulgare*) and thyme (*Thymus* spp.). Heat unlocks the volatile oils in these herbs and infuses the flavor into the food.

The key to determining whether an herb is suitable for use in cooking is to consider how well the flavor is

Oregano is a useful garden plant and seasoning.

preserved when the herb is dried. Drying a woody herb will lock the volatile oils inside the plant. Therefore, any herb that can withstand drying can also withstand the heat of cooking. Leaves like sweet bay (*Laurus nobilis*) and lemon verbena (*Aloysia triphylla*) are also durable, as are the seeds of herbs like coriander, caraway (*Carum carvi*) and dill. Many herbs like French tarragon and mint are equally good when used fresh or dried.

Salad herbs: Perennials and annuals

While nongardeners may find the expense of purchasing several small bunches of salad herbs prohibitive, creating restaurant-quality mesclun mixes is a bargain for the gardener. Even in the United States Department of Agriculture (USDA) zone-five Front Range region, a large variety of salad herbs can usually be grown eight months a year without a cold frame. In the early spring, fresh, tender leaves of hardy perennials like chicory (*Cichorium intybus*) and salad burnet (*Sanguisorba minor*), and biennials like caraway leaf are ready for harvesting. Tender tips of tarragon, chives and lemon balm make great additions to salads and last through the growing season. When the cold-hardy annuals like mâche (*Valerianella locusta*) and chervil (*Anthriscus cerefolium*) wane, the heat-loving annuals like basil and nasturtium (*Tropaeolum majus*) provide a change of pace. An August planting of cress, mustard (*Brassica juncea*) and other cold-hardy annuals often lasts through October.

Pot herbs: Dual purpose

Some culinary herbs prized by herbalists for their nutritive and medicinal constituents are so invasive that most gardeners consider them to be weeds, but organic gardeners and savvy cooks delight in their health benefits. The young, tender leaves of dandelion (*Taraxacum officinale*), lamb's-quarters (*Chenopodium album*) and purslane (*Portulaca oleracea*) add interest and variety to salads, but as age renders them larger, tougher and more bitter, these herbs can be thrown into the cook pot for soups, stews and stir-fries.

Many of these herbs lost favor as Americans became more affluent, but are rapidly gaining popularity with a more health-conscious public, eager to reap the benefits of their newly publicized phytonutrients. These herbs now appear on the menus of some of the trendiest restaurants in America, albeit sometimes under French pseudonyms. Not all pot herbs are considered to be weeds. Lovage (*Levisticum officinale*) stems have a strong celery flavor and durable texture that holds up well in cooking, which some people find preferable in soups and stews that call for celery (*Apium graveolens* var. *dulce*).

Edible flowers: The finishing touch

The simple addition of a few edible flowers can make any meal a memorable occasion. Red clover (*Trifolium pratense*) blossoms are beautiful and delicious in salads. Anise hyssop (*Agastache foeniculum*) petals add outstanding anise flavor. Pineapple sage (*Salvia elegans*) is so sweet, the flowers alone are reason to grow the plant. When herbs start to flower, the leaf is past its prime for flavor, so it is best to grow several plants — some to harvest for leafy greens and others for flowers. While the flowers of most culinary herbs are edible, eat flowers only if you are certain they are of an edible variety and are organically grown.

Joe Coca

Flowers can add a colorful accent to food and drink

The herbal harvest

As anyone who has ever brushed past a row of fresh basil can attest, nothing matches the irresistible, pervasive aroma of fresh herbs. Aroma, nutritional value and flavor all start to fade the moment the plant is plucked. It is a lucky gardener who finds him or herself in the fortunate position to savor herbs straight from the garden or to process them within minutes of harvesting. Rapid drying, infusion or freezing of herbs, locks in significantly more flavor and nutrients than can be obtained from fresh herbs that have been sitting around through harvesting, packaging, transporting and stocking. The freshness of the volatile oils, and the superior flavor and nutrients available in just-harvested plants, is the major incentive to grow your own plants for culinary use.

The best and strongest volatile oils are most concentrated in the actively growing part of the plant. Large leaves below secondary shoots are well past their prime. They are still edible, but the flavor will be weak, the texture tougher and you'll need a larger quantity to get the flavor you desire. You can start harvesting herbs as soon as the plant produces leaves, but leave enough plant so that it will be strong enough to produce more growth. Use the thinnings of dill and cilantro, but wait for the basil to grow several sets of leaves before pinching it back, and never cut into the old wood of hardy perennials that don't die to the ground in the winter.

If possible, harvest your herbs as you need them. If you must harvest ahead of time, cut them early in the day just after the dew has dissipated. Store herbs loosely in plastic bags in the refrigerator, and don't wash them until you are ready to use them.

To wash herbs, float them in small batches in a large bowl of water. Most of the debris will either float or sink. Skim the top of the water. Spread the herbs and pick out any leaves or twigs. This is much easier to accomplish when the herbs are floating than when they become a knotted mass on the counter. Lift the herbs up, swish them around and take them out of the water. Be gentle and don't leave the herbs in the water any longer than necessary as this will cause the volatile oils to dissipate. Immediately remove excess water using a salad spinner or by putting the herbs in a pillowcase and spinning it around outside the house.

Preserving herbs

If you can't use all of your fresh herbs at once, the robust flavors of the herb garden can be easily harvested and preserved for later use. Most fresh herbs can be transformed into fabulous pestos, vinegars and oils, or dried for cooking.

Woody herbs and seeds are best for drying as many fleshy herbs cannot withstand the drying process without losing most of their flavor. Harvest young herb sprigs and rinse them as previously mentioned, being careful not to bruise the leaves. Use a food dehydrator or lay the herbs out on a plastic mesh screen in a warm (not hot), shady place. Give them a fair amount of space to allow good air circulation. When the herbs

Basil and Pesto

by Karin Winans

Joe Coca

Basil comes in many wonderful flavors.

Basil is amazingly easy to grow. Plant it in a hot, sunny location, water often and you will be successful in growing this diverse and wonderful plant. Quite simply, basil loves to thrive and will let you know if you are not treating it well. Basil will usually droop in the heat of the day. If the soil is nearly dry, water well. The leaves should be a deep green. If leaf color pales, fertilize with fish emulsion, which is high in nitrogen and will restore a nutrient balance. Be cautious not to overfertilize, as too much nitrogen will reduce the flavor intensity of basil.

There are many wonderful flavors of basil that you may not be able to find in garden centers so try growing different varieties from seed. Basil needs warmth and plenty of sun. Plant seeds in a germinating mix which includes finely ground vermiculite and place the plant in a warm window for about five to six weeks before planting outdoors. If you keep the temperature between 70° F and 80° F, you will be delighted at how quickly they will grow.

Basil, although a very common culinary herb, is still one of the most revered by fine chefs. Its pungent, spicy flavor lends itself well to many diverse foods and cuisines. Of course, a favorite of basil lovers is pesto. Following is my tried and true pesto recipe. To vary the flavoring, look for more uncommon flavors of basil such as lemon, Thai and cinnamon at specialty grocery stores and farmer's markets, or grow your own!

Basil Pesto

2 cups firmly packed (washed and dried) basil leaves
1 1/2 cups olive oil
3 tablespoons minced garlic
1 cup pine nuts
1/2 cup fresh, finely grated Parmesan cheese
1/2 cup finely grated Asiago cheese
1/2 cup finely grated Romano cheese

Use a food processor to combine basil and olive oil into a coarse paste. Add garlic and pine nuts. Process well. Then mix in the cheeses. Always cover pesto with a thin layer of olive oil to prevent discoloration. Pesto will keep in the refrigerator for up to one week. It also freezes well for future use.

AUTHOR BIOGRAPHY

Karin Winans is a culinary herbalist, who is founder and past president of The Herb Society of America, Rocky Mountain Unit. She has served as the Herb Program Coordinator and is still a frequent teacher for Denver Botanic Gardens' education program. She has also co-chaired three past herb fairs at the Gardens and manages her own organic herb market garden that sells to fine restaurants.

Joe Coca

Woody herbs and seeds, such as this coriander seed, are best for drying.

are completely dry, place them into a clean glass jar with a tight lid and store in a cool, dark, dry place. Dried herbs will continue to lose potency over time, so use them only until the next season's harvest.

The fresh flavor of fleshy herbs can be infused by macerating (or marinating) in oil, but these oils must be used or frozen within a few days. Coating with oil prevents the leaf from drying out or discoloring. The robust flavor of the herb garden can also be easily transformed into fabulous pestos, herbal vinegars and infused oils for use weeks and months in the future.

Although pesto is traditionally made from basil, other herbs render equally outstanding results. Cilantro pesto is a great addition to beans, grains and other Southwestern dishes. Both the stems and leaf can be incorporated, which significantly reduces preparation time. Sorrel makes an outstanding pesto that can be swirled into hot foods at the last minute. Parsley pesto is well-suited to a wide variety of dishes, but its greatest use is as a base to incorporate a small portion of woody herb like rosemary, sage or thyme. The mild parsley complements a wide variety of herbs too overwhelming to incorporate alone in the traditional Parmesan, pine nuts and garlic (*Allium sativum*) mix. Pestos should be used within a few days or frozen for later use. Use them much the same as you would fresh-snipped herbs — put a dollop on top of grilled meats, stir a spoonful into soups and stews, or stuff some into a slit in a chicken breast.

Debbie Whittaker

Garden sorrel, a perennial weed native to Europe and Asia, makes an outstanding pesto.

Julie Behrens

Rosemary is a strong-flavored, woody herb that can be easily preserved.

Herb-Infused Culinary Oils

Infused oils should be reserved for woody herbs like rosemary, sage and thyme. Because these herbs don't retain much moisture, they are not as susceptible to bacterial growth or mold.

Ingredients:

Three to four three-inch sprigs of a woody herb
One cup of olive oil

Wash the herb. Pat dry with clean towels, and thoroughly dry before proceeding. Bruise the herb well into a small amount of olive oil and scrape it into a sterilized jar. Fill the jar with the remaining olive oil and secure with a tight-fitting lid, making sure that the herbs are immersed. Do not shake. Leave the jar in a cool, dark place and strain the herbs out after three weeks.

When making an infused oil, all preparation tools, ingredients and the preparation area must be scrupulously clean. Do not infuse garlic, onion, allium, roots or fleshy herbs with the oil as they may produce harmful bacteria.

Herbal vinegars and infused oils allow adventurous cooks to create unique signature dishes. Their clear,

Herb Vinegars Made Easy

Both fleshy and woody herbs infuse well in vinegar. Herb vinegars are so incredibly easy to make that once you have tried it, you'll wonder why they command such high prices at the grocery store.

Ingredients:

1/4 cup chive blossoms or four-inch sprigs of lemon balm or French tarragon

One bottle of high-quality vinegar, such as white wine or champagne

Simply tuck the blossoms or sprigs into the bottle of vinegar. The ratio should be less than one part herb to four parts vinegar. Cap the bottle and make sure the herbs are totally immersed. Leave the bottle on the counter and turn it over and back up again daily to promote dispersion. After three weeks, strain out the herb. If the flavor is not strong enough, repeat the process.

Infused vinegars make a delicious deglazing sauce for sautéed meats, fish and vegetables. Remove the food to a warm platter: whisk a quarter cup of vinegar into the pan drippings; raise the heat and cook until the vinegar is reduced by half. For a milder, richer sauce, whisk in a tablespoon of butter after the sauce is removed from the stove.

fresh flavors add an inimitable quality to salad dressings and marinades, but they are equally wonderful brushed on simply prepared vegetables, meats and fish, whether grilled, sautéed, steamed or baked.

Growing, preserving and cooking with culinary herbs has a tendency to become a lifestyle — one that presents many options to the gardener. You may want to plant just a few perennial herbs that will offer you food and beauty for years to come; or you may want to spend time in the garden planting, weeding and nurturing annuals from seed. After a few years you may even find yourself in the kitchen concocting outrageous gourmet gifts, coveted by friends and family. Culinary herbs bring pleasure, satisfaction and peace of mind to all who experience them. Eat well and enjoy!

AUTHOR BIOGRAPHY

Debbie Whittaker, the Herb Gourmet, is a food writer and culinary herbalist who specializes in fast, easy, healthy cooking with herbs, as well as their nutritional benefits as preventive medicine. She is a member of the Herb Society of America and the Chef's Collaborative 2000, an organization that promotes sustainable agricultural cuisine.

STANDARDIZED HERBS: ENHANCING NATURE'S POWER

Joe Coca

As the popularity of herb supplements has increased, so has confusion about the different available products.

Since writing my first book on herbs, I've traveled around the country and talked to many different herbal supplement consumers. Several questions always come up. What is a standardized herb? Is it better than a whole herb? What is the difference between a standardized herbal extract and a whole herb? Which one should I take?

I quickly understood that there is a lot of confusion about the differences between whole herbs, standardized herbs and standardized herbal extracts. In order to clarify the terminology, I have put together some important and useful information as I've found no other resources that directly address this issue. I'd like to use this article to communicate some valuable information about this very important topic. My objective is to present ways to help you make better decisions when deciding whether to buy either a whole herb, a standardized herb or an herbal extract product.

Choosing between whole and standardized herbs

The first and most natural of the herbal products for sale are called whole herbs. That's because the whole plant or the active part of the

by Logan Chamberlain, Ph.D.

Joe Coca

Whole herbs use the whole plant or active part of the plant in teas, tinctures or capsules. The herb, therefore, does not undergo change or alteration from its original state.

Joe Coca

Herbs used in standardized herbal extracts endure a series of chemical processes which leave little chemical resemblance to the original herb form.

Standardized Herbal Extracts

Herb	**Treats**	**Standards**
Bilberry (*Vaccinium myrtillus*)	night vision	25% anthocyanocides
Garlic (*Allium sativum*)	blood pressure, cholesterol	5.4mg allicin potential
Ginkgo (*Ginkgo biloba*)	memory, tinnitus, circulation	24% ginkgo flavone, glycosides, 6% terpene lactones
Grape seed (*Vitis* spp.)	varicose veins, circulation	95% proanthocyanocides
English hawthorn (*Crataegus laevigata*)	angina pectoris, CHF	19% ogliomeric procyanids
Kava kava (*Piper methysticum*)	anxiety, stress	29% kavalactones
Licorice (*Glycyrrhiza glabra*)	ulcers, congestion	4% glycyrrhizin
Milk thistle (*Silybum marianum*)	liver disorders	70% silymarin
Saw palmetto (*Serenoa repens*)	enlarged prostate	95% free fatty acids
St. John's wort (*Hypericum perforatum*)	depression	0.2-0.3% hypericin

plant is harvested, dried, then ground up and made into teas and tinctures or put into capsules.

Most herbalists argue that taking the whole plant in its natural state provides synergy with its mix of beneficial compounds and is better than an extract because the natural mix of ingredients is not available when the herb is changed or altered from its original state. Their position is that there is a fine balance of chemical compounds in the herb and that all the benefit you need is contained

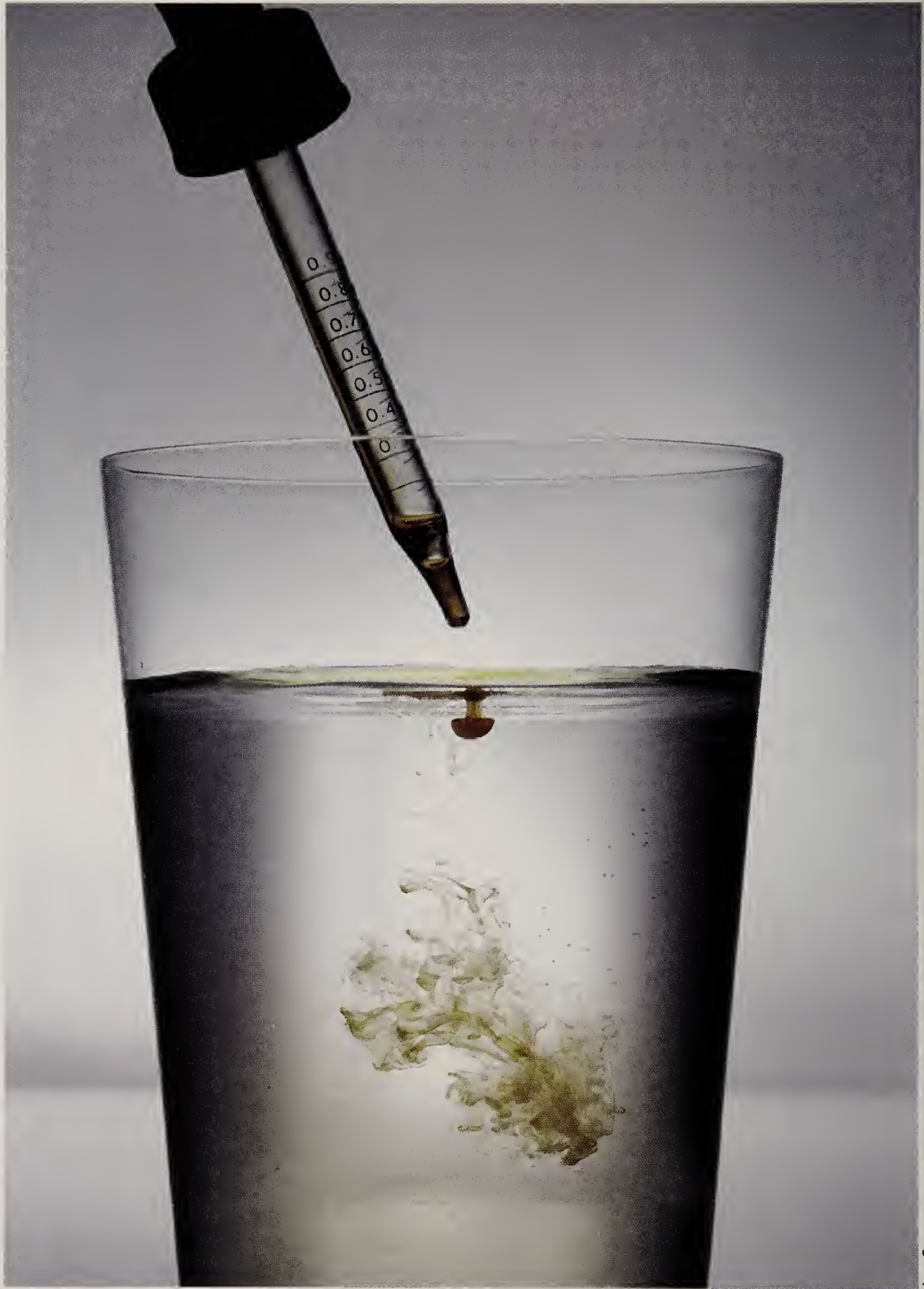
St. John's wort has become a common home remedy for depression.

within those wonderful balanced compounds.

A standardized herb product requires that the manufacturer guarantee a certain level of potency. Many people are in favor of this type of product because it removes the variability found in whole herb products.

Often people confuse the standardized herb with the standardized herbal extract. These are two different product forms. A standardized herb is a whole herb that has additional compounds added to it to guarantee a minimum level of potency. This requires adding a concentrated amount of the active ingredient to the whole herb. Many people have argued that this is not what nature intended and that it alters the product. However, people more concerned with reliability and consistency, like doctors and pharmacists, see standardized herbs as a very positive step in the industry.

A third type or category of herb supplement is the standardized herbal extract. The products in this category are really phytomedicines. I define a phytomedicine as a substance made from a naturally growing plant, that is concentrated and contains only the selected compounds from the original plant found to have therapeutic benefits. Once the herbal raw material is concentrated and refined, there is little chemi-


0.8
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0.4

Joe Cora

It can take up to 50 pounds of raw plant material to yield one pound of concentrated herbal extract.

cal resemblance to its original whole-herb form.

As an example, let's take a common standardized herb, *Ginkgo biloba,* and describe how the standardization process works and what steps are involved to produce the little yellow pill that is the end-product. First, it takes approximately 50 pounds of raw plant material to yield one pound of the concentrated herbal extract. The concentrated herbal substance is taken through extensive chemical extraction processes that finally produce a standardized herbal extract. This is fixed to two of the major marker compounds (ginkgo bilobasides and terpene lactones) that exist in the plant itself.

Once the extracted compound yields the proper established amounts of these chemical compounds, the process is complete. As you can see, this is very different from simply harvesting, drying and grinding an herbal plant to produce a powdered form for capsules. The result of the standardized herbal extraction process is that the new phytomedicine possesses enhanced healing properties that the original whole leaf herb does not.

This argument will not be resolved in the near future. To prove this assertion would take a tremendous amount of scientific research and there is no funding for this type of research at this time.

However, I believe that it would be effective to conduct research on whole herbs because it is less expensive and easier to produce a whole herb supplement than it is to go through all the chemical processes that it takes to make a standardized herbal extract. The consumer would definitely benefit in terms of product price if whole herb products are proven as effective as standardized herbal extracts.

What is interesting is that we now have herbal supplements available that cover this whole spectrum of processes yet consumers really do not understand the difference between products. There are whole herbs at one end that are simply harvested, ground up, and put in the capsules. Then at the other end, there are products made through an elaborate scientific process. When you look closely at this continuum, there is a huge difference between each end of the range, but the products are categorized and sold with little differentiation. That is why you must look at each product label very closely.

New labeling requirements have forced manufacturers to disclose all the ingredients in the product. Additionally, basic nutritional information must now be displayed. To make a wise choice about which product to buy, you must research whether a whole herb or standardized extract has been proven to be most effective. Then look to find out whether the product meets the accepted standards in the clinical

Joe Coca

Ginkgo biloba *is thought to have beneficial properties that affect memory, tinnitus and circulation.*

research and compare potency and prices to select the best product.

The standardization process

The herb standardization process includes the scientific experience of former pharmaceutical drug formulators who are dedicated to producing pure, reliable and consistent products. This approach ensures that these new "drugs" are made from the unique natural compounds that exist in whole herbs.

These scientific processes adopted by herbal manufacturers have many benefits. Standardization ensures that a particular level of potency and purity is achieved, and that the correct species of the herb is used when formulating the product. Since standardization guarantees potency, it is easier for the consumer to determine proper dosage. In summary, a standardized herbal extract may be superior to a whole herb product if you want a guaranteed potency level and high quality product.

From a historical perspective, standardized herbs are relatively new in the herbal product scene. The Commission E in Germany initiated standards in 1978 to make sure that all products have a guaranteed potency. This gave doctors the confidence to prescribe herbal treatments, as consistent dosages lead to more consistent and predictable results.

Standardization usually involves the process of extraction, which adds a number of benefits to the product itself. With standardization, pure herbs are concentrated; therefore you may take a smaller dose to achieve the results you desire. Also, once herbs are standardized and extracted, they can be more easily and quickly absorbed than when the chemical compounds are locked up within the cellulose walls of the plants.

When you decide to compare standardized herbs to whole herbs, always look at the price. Often the whole herb appears to be less expensive, but when you compare the doses and realize that you can take fewer standardized extract capsules, standardized products are typically a better value.

The price of a standardized product is often higher because the whole process of standardization is very complex. Each standardized herbal supplement has a completely different set of formulae to use when standardizing the product. Some products require extreme concentration. In the case of *Ginkgo biloba*, 50 pounds of the plant leaf are required to make one pound of the final product. Other herbs may only require a two-to-one or three-to-one concentration. Science and clinical research have provided the basis for the formulation of these herbal extracts. Continued research will prove which formulae are the best and most reliable and will pave the way for new product development.

TWINLAB LUTEIN
VisionAid
Computer Eyes
Similasan eye drops
Similasan Nasal Spray
NASAL SPRAY
"CYCLONE CIDER"
ECHINAMIDE Cough Syrup
ECHINACEA
Herbal Defense
HerbalNite
SAMBUCOL Black Elderberry
Super Lysine Plus+
COLOSTRUM SPECIFIC
Colostrum Prime Life
NEW LIFE COLOSTRUM
BETA 1,3 GLUCAN
ClearLungs
ECHINACEA GOLDENSEAL
ThymuPlex
Super Immuno Comp
VITA BIOTIC
Immune System Factors
QUICK IMMUNE RESPONSE
ALR FORMULA
LUNG FACTORS
As Comp
SinuGuard
NATROL Ester-C 500 Mg
Ester-C Powder
Liquid ESTER-C

The standardization of herbal products will continue to lead to more reliable and consistent products.

Julia Behrens

The future for standardized herbs

The future holds many new sophisticated products. As science is now being incorporated into product decisions, better formulation will occur. Now that doctors and healthcare professionals are learning more about the value of using herbal medicine, better formulated products will become available to consumers.

Standardized Herbal Extract Benefits

Doctors, pharmacists and consumers may all benefit from using standardized herbal extracts. The major benefits are:

- A reliable, potent and consistent dose of the standardized herbal extract is provided over the duration of treatment.
- The product is more concentrated therefore you may take fewer capsules each day. This is a major benefit because you don't have to remember to take your medicine with you to work or remember to take it at lunch. There is also a cost benefit.
- The cleanliness and purity of a standardized herbal extract is much greater than a whole herb.

The age-old wisdom of herbal medicine is now gaining the respect and attention it truly deserves. As a larger number of people turn to herbal remedies, products are becoming much more reliable and consistent. This is occurring through the process of standardization.

So, even if the controversy between whole and standardized herbs remains, there is no doubt that standardization produces more consistent and reliable herbal products. These are the products that people will feel more comfortable taking on a regular basis. Through these products, the true value of herbal medicine will be ultimately realized on a widespread basis.

Note from the Author:

The information presented in this article is for educational purposes and should not be used as a substitute for advice from a qualified healthcare practitioner. Dosage information is provided as a general guideline. Because we cannot test or investigate all products, services or companies that are mentioned in this article, such appearance should not be construed as an endorsement or a guarantee of quality or integrity.

AUTHOR BIOGRAPHY

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Golden moneywort, wild ginger, cranesbill and lamium weave a textural tapestry.

Excerpted from Herbs in the Garden, *Interweave Press, 1997.*

The textural herb

In any landscape, the gardener may be tempted to make plant choices based on flower color. Sometimes, even when the flower combinations seem perfect, the effect is still unsatisfying, and the gardener wonders why. More often than not, the problem is one of architecture, not color. One of the simplest ways to create a boring garden is to put in plants whose leaves all look alike. Foliage makes up the bulk of the landscape. This is where the varied shapes and textures of herbs — which as a rule are grown more for their leaves than their blossoms — can make strong contributions in every season.

One of the best routes to creating garden interest is by pairing contrasting forms and textures — somewhat confusing terms that are frequently over-used in garden literature. What the advice boils down to is this: put

by Rob Proctor

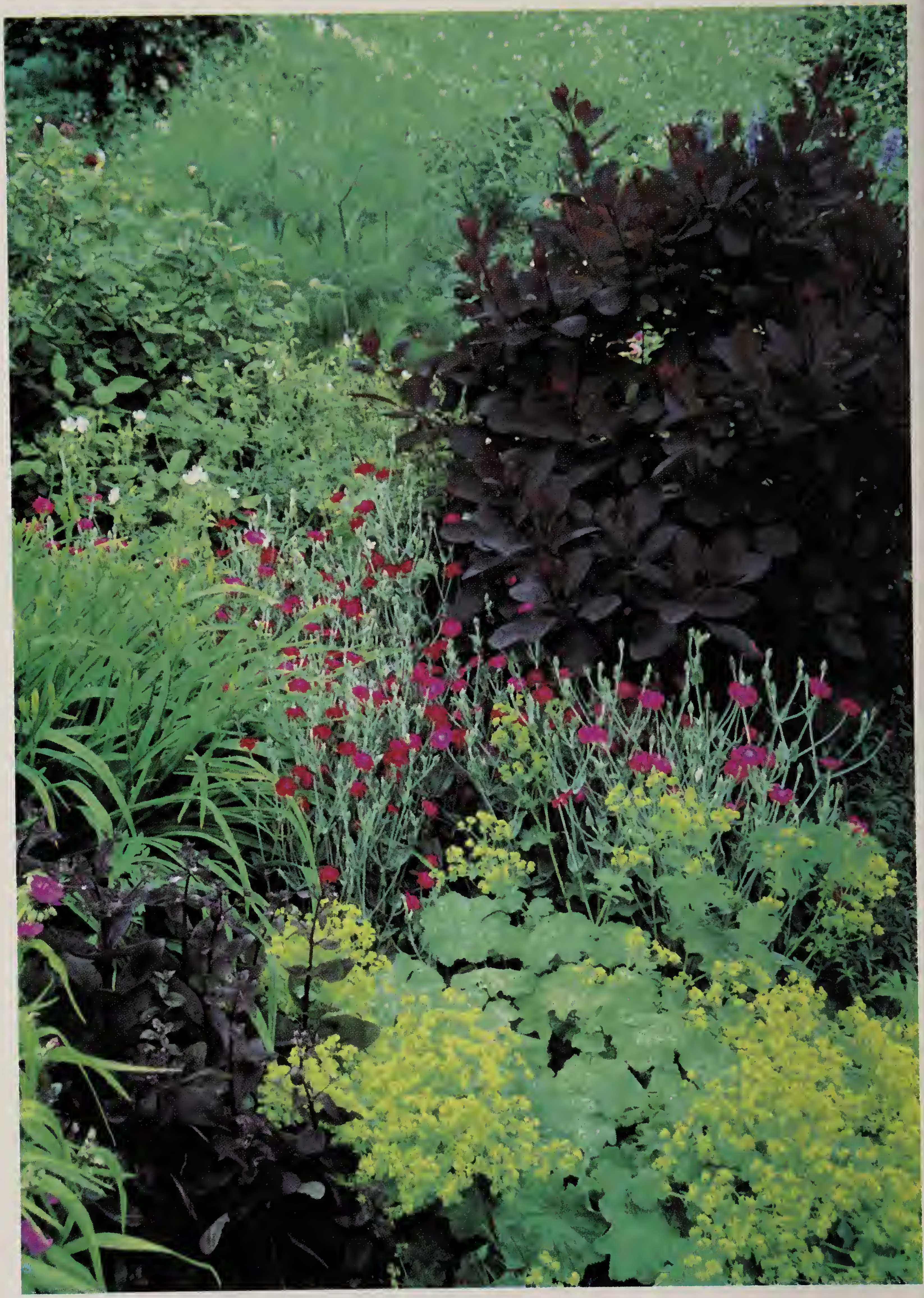
Rob Proctor

The feathery foliage of yarrow accentuates the broad, velvety leaves of lamb's ears.

the big-leaved plants near the little-leaved plants, and put the spiky plants with the roundy-moundy plants. And don't forget to put the fuzzy things with the shiny things.

A bed made up of plants of the same shape and size will be a muddle, no matter how inspired the color scheme. Consider pairing the bold textures of castor beans (*Ricinus communis*), Cuban oregano (*Plectranthus amboinicus*) and flowering maple (*Abutilon* spp.) with the linear foliage of grasses and irises. In the shade garden, the finely detailed foliage of ferns is a delicate foil for the large heart-shaped leaves of brunnera (*Brunnera macrophylla*).

Variation in flower form is another way to create interesting visual effects. Mullein (*Verbascum* spp.), foxglove (*Digitalis* spp.), flowering tobacco (*Nicotiana* spp.) and veronica (*Veronica* spp.) all provide strong vertical elements, but they are best played against other different forms such as the mounded cranesbill (*Geranium* spp.) or the frothy, trans-



The bold pairing of chartreuse lady's mantle and bronze smokebush creates bold contrast.

parent texture of baby's breath (*Gypsophila paniculata*), various grasses or purple top verbena (*Verbena bonariensis*).

Color concerns

Color is probably the design element that gardeners worry about more than any other, but it offers one of the easiest ways to find interesting combinations of flowers and leaves. Light intensity varies from region to region and even from garden to garden, and since it's impossible to subtract green from the garden, forget studying the color wheel. Flower color combinations are not based on how two hues look together, but how they look together with green. Add the variable of other leaf colors — bronze, chartreuse, silver and more — and reliance on classic color-wheel principles of complementary and contrasting colors gets more complicated.

The best way to get started is to do what writers do — get an editor. Ask a friend whose taste you admire to go through your garden with you to edit out the plants that don't work. Keep the best elements and build around them.

For example, an existing shrub, such as *Rosa glauca*, might set the tone for an entire section of border. Edit out the orange daylilies (*Hermocallis* cvs.) and the golden yarrow (*Achillea* sp.) near it and replace them with mauve, pink and lavender-flowered herbs such as star of Persia (*Allium christophii*), pink bee balm (*Monarda didyma*), catmint (*Nepeta × faassenii*), *Stachys macrantha*, chives (*Allium schoenoprasum*), lavender (*Lavandula* spp.) and pinks (*Dianthus* spp.). Introduce drifts of purple sage (*Salvia officinalis* 'Purpurascens') and bronze fennel (*Foeniculum vulgare* var. *rubrum*) for drama and silver artemisia (*Artemisia* spp.), cardoon (*Cynara cardunculus*) and partridge feather (*Tanacetum densum* var. *amani*) for highlights. As new plants in this color range catch your fancy, and they always do, the scheme will evolve.

Any color scheme carried to its extreme can produce a boring border. There's a wide range of choices for complementing and contrasting flower colors within a given scheme. The critical element is using the right intensity. Strong colors need strong color complements and subtler shades need equally subtle color complements.

Some people argue that white flowers calm brilliant colors, but the other camp, to which I belong, thinks that white tends to enliven them. Feverfew's (*Tanacetum parthenium*) mounded, round shape and its flurry of white blooms accent spiky veronica or Jupiter's beard (*Centranthus ruber*). It's an ideal plant to tie together a pastel grouping of plants of various shapes while bringing out the best of each.

Western gardeners have embraced

Rob Proctor

A flurry of snow daisies and Veronica 'White Icicle' cool a summer day.

a Turkish relative of feverfew called snow daisy (*Tanacetum niveum*) for its glorious display of small white daisies above silver-gray foliage. It puts up with heat and drought and thrives as well as feverfew, but if allowed to go to seed, usually dies the second season. I cut most snow daisies down in midsummer to prolong their lives but let a few set seed to keep the line going.

Annual additions

New gardens need time for perennial plants to reach full size, and there's always an abundance of bare earth for the first year or two. One of the best ways to deal with this problem is to fill the spaces with annuals, but instead of the usual bedding plants sold by the plastic six-pack, try some herbs. Herbal candidates for the new border include nasturtium (*Tropaeolum majus*), borage (*Borago officinalis*), castor bean, calendula (*Calendula officinalis*), Chinese forget-me-not (*Cynoglossum amabile*), amaranth (*Amaranthus* spp.), nico-

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The striking beauty of dill and perilla make them worthwhile, yet unusual, annual additions.

The inventory in Denver Botanic Gardens' Herb Garden includes nearly 300 types of culinary herbs, medicinal herbs and dye plants.

The Herb Garden at Denver Botanic Gardens

by Lainie Jackson

The Herb Garden at Denver Botanic Gardens was started in 1964 by the Guild, known then as the Junior Committee. Over the years, money has been raised by selling calendars, making vinegar (which continues today) and hosting the Terrace and Garden Tours for many summers.

Persis Owen designed the west side of the garden, a formal bow knot of red brick with a central statue of 'Boy with a Frog' by Elsie Ward Hering. It features culinary herbs and a few butterfly plants. It is bordered by upright yews (*Taxus* sp.) on the south, and Lavalle hawthorns (*Crataegus* × *lavallei*) on the north. The later addition of the Falkenberg border on the west side includes a hedge of roses, and four large urns which lead to the Scripture Garden.

The plantings in the knot garden emphasize the many curved lines of the brick paths, and contrasting foliage colors of grey, green and purple. The deep green juniper Calgary Carpet™ (*Juniperus sabina* 'Monna') surrounds the grey statue. Four moon-shaped beds have plants of the onion (Alliaceae) family, tender French (*Origanum onites*) and Italian oreganos (*Origanum* x *majoricum*) and Italian parsley (*Petroselinum crispum*) and cutting celery (*Apium graveolens*). Sixteen different mints (*Mentha* spp.) grown in sunken pots frame the back side of the knot garden. Purple sage (*Salvia officinalis* 'Purpurascens'), blue anise-hyssop (*Agastache foeniculum*), wild marjoram (*Origanum vulgare*) and lavender-flowered caraway thyme (*Thymus herba-barona*) are used as accents.

Shade tolerant herbs like angelica (*Angelica archangelica*), sweet cicely (*Myrrhis odorata*), skirret (*Sium sisarum*), tender cardamom (*Elettaria cardamomum*), Costa Rican oregano (*Lippia graveolens*), French sorrel (*Rumex scutatus*) and sweet woodruff (*Galium odoratum*) are featured in a south border of the knot garden. These are white-flowering plants which draw the eye to the farthest areas. Included in a sunny patch are the toughies: horseradish (*Armoracia rusticana*), Jerusalem artichoke (*Helianthus tuberosus*) and comfrey (*Symphytum officinale*).

In the 1970s the east portion of the Herb Garden was added. Since the Herb Society of America defines an herb as a plant that is for use or delight, this area was added to display dye plants, medicinal plants and fragrant plants as well. A sandstone sundial is the focus of this garden, which was designed by Cathy Swift. Grape (*Vitis* cvs.) arbors give shade along the south border and between the two sections of the herb garden. A rustic gazebo adds a cool, comfortable place to sit or have small meetings.

A formal bow knot of red brick paths is accentuated by contrasting foliage colors.

The central beds around the sundial are planted with red 'Rubin' basil (*Ocimum basilicum* 'Rubin'), faced with various ornamental thymes (*Thymus* spp.) and backed by a striking oregano (*Origanum laevigatum* 'Herrenhausen'). The trees in this area are blue ash (*Fraxinus quadrangulata*), red horse chestnut (*Aesculus* x *carnea*) and a recently planted ginkgo (*Ginkgo biloba*) near the gazebo. A shrub rose, *Rosa primula*, is from a cutting of one that Governor Evans brought across the prairie to Colorado in the 1800s. A collection of scented geraniums (*Pelargonium* cvs.) is just to the side of the gazebo and most plants here are fragrant — the tender myrtle shrubs (*Myrtus communis*), tall marigold Nelsonii (*Tagetes nelsonii*), pineapple sage (*Salvia elegans*) and lemon verbena (*Aloysia triphylla*). A large pot of mixed herbs graces the steps of the gazebo and two more pots of very large bay laurel (*Laurus nobilis*) mark the entrance to and from the Romantic Gardens. An *Artemisia* collection, in a bed of hard Colorado clay, features specimens of many heights and foliage colors. In the foreground of this bed is yellow yarrow (*Achillea taygetea*) and various tender lavenders (*Lavandula* spp.) as a border. My favorite lavender here is French lavender (*Lavandula dentata*), which has a lovely soft, furry spike.

Come see, feel and smell the plants of the Herb Garden. The scents of the oils produced by the herbs will give you as much pleasure as viewing them.

AUTHOR BIOGRAPHY

Lainie Jackson, a volunteer at Denver Botanic Gardens since 1960, selects the plants for the Gardens' Herb Garden. With assistance from the Denver Botanic Gardens' Guild, she also manages the Herb Gardens' renewal and maintenance each year. Lainie holds a Bachelor of Arts in Botany and is also a member of the Garden Club of Denver, Herb Society of America and is the co-chair of Hudson Gardens' Herb Garden.

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The satiny flowers of bread-seed poppy dance among spikes of lemon mint and silver artichoke foliage.

tiana, perilla (*Perilla frutescens*), dill (*Anethum graveolens*), fennel (*Foeniculum vulgare*), annual salvias (*Salvia splendens* and *Salvia viridis*), red and yellow orach (*Atriplex hortensis*), viper's bugloss (*Echium vulgare*), bread-seed poppy (*Papaver somniferum*), and varieties of basil (*Ocimum basilicum*) and verbenas.

Because most of these annual herbs self-sow, they may become permanent parts of the border. Even as the perennials fulfill their promise, the annuals will find a way to keep a toehold in the border. This is a good thing because self-sowers can help any design, but few are strong enough to over-power a stalwart perennial.

Annuals also disguise the fading foliage of spring bulbs. Annuals interplanted with bulbs will begin to flourish just as the bulb foliage looks its worst, reducing the temptation to cut it off before it matures.

Border classics

The line between herbal and ornamental gets somewhat blurred when it comes to the classics. Both perennial and annual traditional herbs with handsome good looks are no strangers to herbaceous borders.

A silver and gold border could easily be built around the classic herbs that have traditionally been incorporated into borders. Such a border could be comprised of perennials such as lavender cotton (*Santolina chamaecyparissus*), valerian (*Valeriana officinalis*), costmary (*Tanacetum balsamita*), elecampane (*Inula helenium*), garlic chives (*Allium tuberosum*), pearly everlasting (*Anaphalis margaritacea*), feverfew, Canadian burnet (*Sanguisorba canadensis*), Jerusalem sage (*Phlomis russeliana*), and every imaginable species of *Artemisia* and *Achillea.* White-flowered forms of coneflower (*Echinacea pupurea* 'Alba' or 'White Swan') and lavender would be perfect. A clump of Adam's-needle (*Yucca filamentosa*) could provide a strong vertical accent. Annual sunflowers (*Helianthus annuus*), golden chamomile (*Anthemis tinctoria*), euryops daisy (*Euryops pectinatus*), curry plant (*Helichrysum italicum* spp. *serotinum*), and okra (*Abelmoschus esculentus*), with its pale yellow hibiscus flowers, would also be good companions in such a border.

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Herbs shine in a silver and gold border.

The classic border herbs, so familiar that we sometimes take them for granted, are valuable perennials and

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The yellow flowers and blue foliage of rue underscore blue cupid's-dart and pink lavatera.

annuals in any garden. Feverfew is pretty with almost anything and pairs well with rose campion (*Lychnis coronaria*) and nicotiana, but it may be at its best surrounding Asiatic hybrid lilies (*Lilium* ×) — a combination that looks like a florist's flower arrangement. Cultivars of feverfew include 'Golden Ball', nine inches tall with solid yellow flowers; 'Golden Moss', six inches tall with chartreuse leaves and single blossoms with white rays and yellow disk; 'White Bonnet' and 'Plenum', two feet tall with double white flowers; 'Tom Thumb White Stars', nine inches tall with white pompons; and 'Snowball', one foot high with double ivory blossoms.

Costmary, also known as Bible leaf, forms a dense, long-lived clump that puts on a late-summer show of yellow daisies on stems three feet high above flat, wide basal leaves that were once used as prayer-book markers. The variety *tomentosum* looks much like the species but smells strongly of camphor.

Rue (*Ruta graveolens*) works much like feverfew in combinations. The leaves of the species are a delightful shade of blue-green, and they have a fine texture that can showcase blossoms. Some gardeners prefer the Aqua Velva color of the cultivar 'Jackman's Blue'. One favorite companion for rue is rose mallow (*Lavatera trimestris*). The

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The broad foliage of grapes makes a good backdrop for frothy feverfew and the seedheads of red orach.

satin sheen of the petals of this old-fashioned annual appears all the more luminescent against the rue leaves. Tweedia (*Tweedia caerulea*) enhances the grouping. Its unusual turquoise stars complement rue's foliage but don't compete with the rose mallow blooms. Rue is also superb in combination with the linear shapes of ornamental grasses, especially those that echo its color, such as blue lyme grass (*Elymus racemosus* 'Glaucus') or blue fescue (*Festuca glauca*).

Artemisias work the same magic as rue. Their leaves are usually even more finely textured and most gleam of silver. Favorites include the hybrids 'Powis Castle' and 'Huntington', which form luxurious silver clouds that invite adventuresome pairings, such as encircling clumps of sedum 'Autumn Joy' (*Sedum telephium* 'Autumn Joy'), its red plates of blossoms all the more brilliant against the artemisia's silver threads.

Among the most beautiful of all herbs are the purple coneflowers (*Echinacea* spp.), some of which have become a staple in both the medicine cabinet and the flower border. The best-known species, *E. purpurea*, features a bristly orange and brown cone and distinctive lavender-pink ray florets. Breeding has raised these ray florets from a drooping position to a perky horizontal one, but the flower is lovely in either

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The starred flowers of rudbeckia float amidst a cloud of Artemisia *'Silver King'*.

Favorite Herbs in the Landscape

Name	Height/Spread	Flower Color/Bloom Season
Achillea 'Anthea' (yarrow)	18-24 in./18-30 in.	pale yellow/summer
Pretty with lavender and bellflowers		
Alchemilla vulgaris (lady's mantle)	2 1/2 ft./2 1/2 ft.	chartreuse/summer
The quintessential cottage garden plant that looks great with nearly everything except plastic flamingos.		
Allium christophii (star of Persia)	12-18 in./8 in.	metallic lavender/summer
Despite rumors to the contrary, performs better in partial shade in moderately moist soil; enjoy the 4-8 inch dry flower heads.		
Allium tuberosum (garlic chives)	20 in./20 in.	white/late summer
Combine the sweet-scented flowers with the gray foliage of pinks and artemisias.		

Name	Height/Spread	Flower Color/Bloom Season	
Anethum graveolens **(dill)**	**24-48 in./12-15 in.**	**chartreuse-yellow/summer**	Finely dissected, glaucous foliage adds an airy look to borders. It's too pretty to only use for pickles.
Artemisia **× 'Powis Castle'**	**2-3 ft./4 ft.**	**yellow/summer**	Fine-textured clouds of silver foliage set off white-flowered iris or lavatera to perfection.
Artemisia ludoviciana **(white sage)**	**2-4 ft./indefinite**	**yellow/summer**	Selections include 'Silver King', 'Silver Queen' and 'Valerie Finnis'; none is well-behaved but all are worth confining.
Atriplex hortensis **(orach)**	**24-48 in./6-12 in.**	**inconspicuous/summer**	Gold ('Aureus') or burgundy ('Rubra') leaves; showy seed heads. Deadhead to prevent reseeding (both come true from seed).
Foeniculum vulgare **(fennel)**	**4-8 ft./1 1/2 -4 ft.**	**sulfur yellow/summer**	'Rubrum', bronze fennel, makes a smoky haze that serves as a splendid backdrop for poppies, irises and almost everything else.
Galium verum **(our lady's bedstraw)**	**2-3 ft./1 1/2 -3 ft.**	**yellow, with lime/early summer**	A good long show of flowers and seed heads, but stalks may need support to prevent flopping.

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Spikes of clary sage compliment mounds of pale yellow yarrow and magenta cranesbill.

Name	Height/Spread	Flower Color/Bloom Season
Dianthus plumarius (cottage pink)	**12-18 in./18 in.**	**white or pink/June to July**
Gray foliage is attractive year round, but the early summer flowering is glorious.		
Echinacea purpurea (purple coneflower)	**48 in. /18-24 in.**	**purple/summer**
‘White Swan’, with white flowers grows to about 18 inches tall.		
Ruta graveolens (rue)	**24 in./18 in.**	**yellow/summer**
‘Jackman's Blue’ has the bluest foliage; ‘Variegata’ has cream-edged foliage.		
Nepeta sibirica (catmint)	**3 ft./indefinite**	**blue/summer**
A favorite for the color and duration of the flowers, even if you have to excuse its rambling ways.		
Origanum laevigatum (Greek oregano)	**10-30 in./36 in.**	**purplish pink/August to Sept.**
‘Herrenhausen’ and ‘Hopleys’ are stunning in late summer.		
Perilla frutescens (red shiso)	**2-4 ft./1-2 ft.**	**white/summer**
‘Atropurpurea’, with bronze nearly metallic-looking leaves, self-sows in many of our borders and even in containers.		
Salvia forskaohlei	**3-4 ft./2-3 ft.**	**purple/summer**
Several shows of flowers are possible if the plants are cut well back after each flowering.		
Salvia sclarea (clary sage)	**3 ft./2 ft.**	**mauve-pink bracts/summer**
‘Turkestanica’ is bigger, bolder and brighter.		
Santolina chamaecyparissus (lavender cotton)	**6-20 in./12-24 in.**	**yellow/summer**
Great behind fall blooming colchicums; ‘Lemon Queen’, ‘Nana’, and ‘Pretty Carol’ have silver foliage.		
Stachys byzantina (lamb's ears)	**12-30 in./indefinite**	**pink/summer**
‘Countess Helene von Stein’ (‘Big Ears’) offers larger leaves; ‘Phantom’ has variegated foliage; ‘Primrose Heron’ is chartreuse; non-blooming ‘Silver Carpet’; is a valued edging plant.		
Stachys officinalis (wood betony)	**12-30 in./18-30 in.**	**magenta, pink or white/summer**
Lovely with garden sage and our lady's bedstraw.		
Tanacetum niveum (snow daisy)	**2 ft./2 ft.**	**white/summer**
A new western favorite that tolerates drought but rots out in the East; let a few plants self-sow.		
Tanacetum parthenium (feverfew)	**8-36 in./8-24 in.**	**white or yellow/summer**
The golden form 'Aureum' has become my favorite for almost any situation in sun or shade.		
Thymus x citriodorus (lemon thyme)	**4-6 in./24 in.**	**pink/late spring**
'Argenteus' has showy golden foliage; 'Variegatus' tends to revert to green.		
Verbascum bombyciferum (silver mullein)	**4-6 ft./2-3 ft.**	**yellow/summer**
'Arctic Summer' is noted for its extra-silver foliage.		

pose. Many cultivars have been selected, including white ones like 'White Swan', which expand the options for artistic uses.

Perhaps because yarrows grow so readily and reliably, at least in dry climates, some look down their noses at them. Those who prefer plants that are rare and difficult to grow should skip the genus *Achillea* altogether, for it is full of great, nearly foolproof border perennials. Tops on the list are cultivars derived principally from *A. filipendulina*, such as the mustard yellow 'Coronation Gold', bright yellow 'Gold Plate' and golden yellow 'Parker's Variety'. Granted, these robust, brilliant cultivars easily overwhelm a delicate pastel theme, but their height (three to four feet), attractive ferny, sage-green foliage, and bold show of dense, flat-headed flower clusters are worthwhile.

Some yarrows should be viewed with suspicion because of their invasiveness. *A. millefolium* can rapidly spread out of control in moist, rich soil. Although its white or pale pink flowers have their charms, selected varieties are much prettier and behave somewhat better, but I grow them "lean and mean" to keep them in bounds. Their names describe them well: 'Cerise Queen', 'Lavender Lady', 'Paprika', 'Fire King', and 'White Beauty'. 'Summer Pastels' comes in a variety of subtle shades ranging from buff pink, salmon and apricot to pale yellow.

The main drawback to growing bee balm is its susceptibility to powdery mildew. Most forms of *Monarda didyma* attract mildew like a magnet, but some new cultivars such as 'Marshall's Delight', appear to deliver on the promise of mildew resistance. I've rarely had mildew problems with 'Croftway Pink' or the hybrids that involve *M. fistulosa*, such as 'Violet Queen' and 'Prairie Night', but not every gardener can make that claim.

English lavender (*Lavandula angustifolia*) is one of a few species of lavender that survives the rigors of winter below the USDA hardiness Zone 6. A pretty, useful plant in many ways, its best-known cultivars are the lavender-blue 'Munstead' and the deeper violet-blue "Hidcote Blue'. Pink forms include pale 'Rosea', 'Hidcote Pink', and true pink 'Miss Katherine'.

These are among the easily cultivated herbs that have gone mainstream, valued as much for their ornamental properties as for their heritage of usefulness. Their success should encourage gardeners to integrate other herbs into their borders.

AUTHOR BIOGRAPHY

Rob Proctor, Director of Horticulture at Denver Botanic Gardens, is a nationally known horticulturist, lecturer, speaker, author, illustrator and photographer. He is the author of nine books and is a frequent contributor to several national magazines.

Joe Coca

Natural ingredients can provide an economical and ecologically friendly approach to homekeeping.

by Sandy Maine

Excerpted from Herbal Homekeeping, *Interweave Press, 1999.*

The next time you dash down the cleaning-products aisle of your local supermarket, STOP! Look at how many cleaning products are available and the shelf-feet of space they take. I see an amazing irony on those shelves: All those cleaning products, offered to make your housekeeping duties easier, actually complicate life. They also waste valuable natural resources, time, money and space.

Have you read the labels of these "helpful" products? Many give poison-center phone numbers, toxic-waste disposal information and disclaimers for allergic reactions, and for good reason. The ingredients of these products are poisonous, toxic and downright hazardous, yet they're promoted as our very best housekeeping friends.

Is there a better way? Of course there is! And I have found it to be a satisfying, economical and ecological way too! Why not simplify your homekeeping needs? Why not learn how to incorporate the sensual, healing effects of the herbal world into your own homekeeping cupboard of favorite household formulations?

Natural homekeeping

There are twenty bad reasons why I'm writing this article: ammonia, bleach, butyl cellosolve, cresol, dye, ethanol, formaldehyde, glycol, hydrochloric acid, hydrofluoric acid, lye, naphthalene, paradichlorobenzenes, perchloroethylene, petroleum distillates, phenol, phosphoric acid, propellants, sulfuric acid and trichloroethylene. I found these chemicals listed on the labels of cleaning formulas. All are dangerous and most are considered hazardous waste. Are they fun to use? No! Effective? You bet, but they cost plenty, both in dollars and risk to the environment.

Here are the good reasons for this article, along with descriptions of the ways they benefit homekeeping:

Baking soda (sodium bicarbonate) is a mild alkali that is useful in a variety of cleaning applications.

White vinegar, a slightly acidic liquid, is useful in many cleaning formulas. (Heinz® vinegar is made from grains, but many others are made from nonrenewable petroleum alcohols, so I prefer Heinz.)

Sodium lauryl sulfate powder (SLS) is a simple, safe, and effective detergent derived from coconut oil. Its power to clean surfaces is stronger than that of soap.

Unscented bulk castile soap, like SLS, serves as a surfactant by helping to loosen and wash away dirt. A several-pound bar that can be grated into formulae when needed is very handy.

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Lemon, lime and grapefruit juices, fresh or in concentrate, do more than smell great: they're acidic and antibacterial and make a lively addition to any cleaning formula.

Borax (sodium bromate) is a mildly alkaline, water-soluble salt. It loosens dirt and stains while removing odors. Borax is usually available in supermarkets, but it's offered by mail too.

Carnauba and olive oils are excellent additions to wood cleaners because they recondition and polish the surfaces.

Beeswax turns formulae into pastes for waxing and shining.

Lanolin, a natural oil extracted from wool, restores some of the fiber's natural sheen and water repellency when added to wool-washing soaps.

Clay powder is a very mild abrasive. It also easily absorbs essential oils and makes them easier to disperse in powdered cleaning formulae.

Pumice is finely ground volcanic rock; add it as an abrasive to scrubbing compounds for big jobs.

More good reasons: Essential cleaning oils

Distilled from plant roots, rinds, flowers, seeds and resins, essential oils are highly concentrated and intensely scented. For homekeeping, they offer important cleaning and disinfectant benefits.

Some essential oil scents lift the spirits. An entire field of study, aromatherapy, deals with the healing potential of aromas. It's based on the idea that the human olfactory nerves lead directly to the brain's emotional center, the limbic system, so perhaps one's emotional well-being can be improved by the judicious use of scents.

I think aromatherapy works, and I like to employ its principles in homekeeping. These are my favorite essential oils for cleaning. They are effective, easy to obtain, and not too expensive. A little goes a long way!

Lavender oil is a disinfectant. Its calming scent is often used by aromatherapists to ease tension, anxiety and depression.

Lemon, orange and grapefruit oils are tough degreasers with refreshing clean scents that can alleviate depression and fatigue.

Lime oil has a lighthearted citrus scent that is so delicious, it's easy to forget how well it performs as a degreaser and general cleanser. In a pinch, mix a few drops of this oil with a couple of tablespoons of baking soda for a slightly abrasive kitchen scrub.

Eucalyptus oil disinfects while helping relieve stuffy noses. It's an excellent cleaning choice if you are fighting off a cold!

Tea tree oil, distilled from the Australian *Melaleuca alternifolia* tree, is effective against bacteria, fungus and some viruses; it's terrific for cleaning when there's illness in the home. Inhaling tea tree's strong scent eases congestion.

White cedar oil disinfects and provides an uplifting scent. It's another good choice when illness is present.

Pine oil is a fine old standby for homekeepers. This plentiful and inexpensive essential oil is a degreaser and a bit of a disinfectant. Its clean, outdoor scent stimulates alertness – sometimes helpful during cleaning.

Essential oils are not the same as the synthetic scent oils that you can find at many crafts stores. Such chemically contrived oils don't originate from plants and they cannot offer the cleaning and therapeutic benefits of essential oils. When using essential oils, remember that they are highly concentrated and as a rule should not be applied directly to skin or to household surfaces. Never ingest essential oils; should this happen by accident, do not induce vomiting; seek immediate medical help.

Useful equipment

To make your herbal cleaning formulas, you will need measuring cups and spoons, wide-mouth and narrow funnels. Use large stainless steel or glass bowls rather than ceramic or plastic ones that may absorb essential oil scents.

Gather up an assortment of spray bottles, squirt bottles, and shakers with flip tops (one of my favorites is an old Parmesan cheese container). Assorted jars or plastic storage tubs are handy, too. All these will be used to store your products. For labeling the containers, you'll need labels, markers and tape.

Joe Coca

Joe Coca

Carnauba and lavender combine to make a protective furniture wax.

Recipes

Carnauba and Lavender Furniture Wax

This paste wax will clean, condition and polish wood surfaces while providing a protective coat of wax. Fine carnauba wax is derived from the leaves of the palm tree *Copernicia prunifera*. This formula is lightly scented with lavender essential oil, which enhances its cleaning power. Use a circular motion to rub it onto wooden floors and antique furniture, buff with sheep's wool and a soft cotton cloth, then enjoy the peaceful calm offered by the scent of lavender and the soft glow of the polished wood.

1/4 cup carnauba wax
2 tablespoons beeswax
1 1/4 cup olive oil
1 teaspoon lavender essential oil

Melt waxes over low heat in small saucepan. Stir in olive oil, then lavender oil. Pour mixture into a container of tin, plastic or glass and allow to harden.

Eucalyptus, Lavender and Tea Tree Spray Cleaner

This spray cleaner has a triple crew to disinfect surfaces, wipe out mold, and discourage its return. Eucalyptus, lavender and tea tree are all known for their antimicrobial properties. Together, they smell exquisitely clean, and they know how to get the job done.

1 teaspoon sodium lauryl sulfate
1 teaspoon borax
2 tablespoons white vinegar
2 cups hot water
1/4 teaspoon eucalyptus essential oil
1/4 teaspoon lavender essential oil
3 drops tea tree essential oil

Mix all ingredients together and stir until dry ingredients dissolve. Pour into spray bottle for use and long-term storage. To use, spray as needed on any surface except glass. Scrub and rinse with a clean, damp cloth.

Lavender-Ginger Suds Upholstery Cleaner and Rug Shampoo

This is a high-suds cleaner. It's actually the suds and scrubbing (provided by you) that do the tandem job of lifting the dirt and smells from rugs and plush furniture. The lavender and ginger essential oils will help if animal smells are a problem.

Before tackling the entire job, test-clean any light or unusual fabrics — better safe than sorry! And remember not to soak your furniture; use only the suds for cleaning.

4 cups water
1 cup white vinegar
3 tablespoons sodium lauryl sulfate
2 teaspoons baking soda
1/8 teaspoon lavender essential oil
1/8 teaspoon ginger essential oil

Mix all ingredients together and fill a hand-held rug/upholstery shampoo bottle half full. Shake the bottle vigorously and shampoo your furniture or rug using small circular motions. Try not to penetrate fabrics with much more than a thin layer of suds, but scrub the sudsy area well.

Lemon Metal Cleaner

No need to buy four different metal cleaners and keep them locked up under the sink, or to subject your sinuses, lungs and eyes to the stinging, burning sensation that most metal cleaners cause. This simple formula will clean any metal except aluminum. To clean aluminum, substitute cream of tartar for baking soda and omit the salt.

Fresh squeezed juice of 2 lemons
1/3 cup baking soda
1 teaspoon fine salt
6 tablespoons clay powder

Mix all ingredients together until you have a paste. Add water or more clay if needed for consistency. Rub paste onto metal with extremely fine steel wool and allow to sit for 15 minutes. Wash off with a sponge and clear water. Polish the metal with a soft piece of felt, flannel or sheep wool. For stubborn tarnish, repeat the process.

Eucalyptus-Mint All-Purpose Disinfecting Soft Soap for Kitchen and Bath

This soap can be used for dishes, handwashing, floors, stoves, refrigerators, sinks and hands. It's mild to the skin but effective enough to get cleaning jobs done. The eucalyptus and mint provide a disinfecting quality as well as a fresh scent; any areas washed with this soap will be undesirable to crawling insects and flies. They'll stay away for quite a while.

5 cups grated castile soap
1/2 cup baking soda
1 teaspoon borax
6 cups hot peppermint tea
1 teaspoon eucalyptus essential oil

Put grated soap into a 3-quart stainless steel saucepan and add hot mint tea. Simmer for 15 minutes on low heat. Add baking soda, borax and eucalyptus oil. Store in a labeled plastic jug or squirt bottle. Shake before using.

Delicate Garment Soap with Lavender

I have always enjoyed handwashing my most delicate clothing. With my lavender soap I prepare a sink full of warm, sudsy water, then immerse the garments slowly, one at a time. I gently lift them in and out of the water, protecting the lace and tiny seams while enjoying the soft swish of the water and the wafting scent of lavender flowers. When my special clothes are rinsed, I let them dry outdoors; the bees often visit to enjoy the lavender fragrance that lingers.

8 tablespoons sodium lauryl sulfate
4 tablespoons grated castile soap
2 teaspoons clay powder
1/4 teaspoon lavender oil

Mix clay and lavender oil with a small whisk or fork. Add remaining ingredients and blend at high speed in a blender. (This will not ruin your blender for food use). Store in a plastic container. To use, sprinkle 1 tablespoon of powder into a sink of warm water and swish the water until the powder is dissolved. Then add garments and wash; rinse thoroughly and dry.

Grapefruit Abrasive Cleanser

This cleanser gets its punch from finely ground pumice, a volcanic rock dust. It's comparable to a soft scrub and can be used for tubs, sinks, tiles and even hardworking hands that have been stained with grease. The lingering scent is pungent and fresh!

1 cup fine-grade pumice
1/2 cup clay powder
2 tablespoons grapefruit essential oil
1/4 cup baking soda
1/3 cup sodium lauryl sulfate
1/2 cup boiling water (or enough to make a thick paste)

Mix all ingredients together and stir. Store in a labeled airtight container.

To use, apply gently with a damp sponge or cloth and scrub. Use a light touch on fiberglass fixtures.

Spritz-and-Spray Toilet Bowl Cleaner

The baking soda and vinegar in this formula dissolve mineral buildup, while the oils loosen grime and give a fresh, clean scent.

1/2 teaspoon sodium lauryl sulfate
2 tablespoons baking soda
2 tablespoons vinegar
1 teaspoon orange essential oil
1 teaspoon grapefruit essential oil
2 cups water

Mix all ingredients in a 4-cup measuring cup or a bowl. When you mix the vinegar and baking soda, it will foam. Let this mixture stand for 10 minutes before pouring into a spray bottle.

The gentle and calming scent of lavender provides a good basis for a delicate garment soap.

Once-a-Year Laundry Concentrate

Life will be better with this simple and effective formula for the laundry in your life and you'll run out of laundry powder only once a year. You won't be rushing to the store on short notice, filling the trashcans with plastic or paperboard containers, or wondering if your laundry powder damages the environment.

The following formula will last a year for an average family of four that generates five loads of wash per week for 12 months. Make more or less according to your needs.

1/4 cup clay powder
2-3 tablespoons essential oil of your choice
13 cups borax
12 cups baking soda
4 cups sodium lauryl sulfate

You may want to use a dust mask or tie a scarf over your nose and mouth when mixing this formula.

Using a small whisk or fork, mix the clay powder with the essential oil. Add the remaining ingredients and mix well in a 2- or 3-gallon pail. Use 1/8 cup of laundry powder per load.

Lemon-Mint Window Wash

If you live where flies routinely cause problems in the summer, you'll love this recipe. Your windows will be sparkling clean, and the fresh lemon juice and peppermint oil in the formula discourage the pesky critters from perching on your windows again.

Before you wash the windows, whisk away dust and dead bugs from the casing using a small, hand-held broom. For the shiniest windows, use sheets of newspaper (black and white only) to scrub and shine them. The newspaper ink may darken your hands, but it shines the windows without streaking.

Juice from one fresh lemon
2 cups water or club soda
1/2 teaspoon peppermint essential oil
1 teaspoon cornstarch

Mix all ingredients and pour into plastic spray bottle. Shake well before using.

Sleepy-Bye Soap for Bed Linens

This soap is one part extravagance and all pleasure. Bed sheets washed with this lavender-scented soap will soothe the longest, most difficult day. Why? Because lavender oil's scent has the power to calm the nerves and ease the mind. I enjoy hanging my sheets to dry on a shady outdoor line to preserve the lavender scent.

1/4 cup clay powder
2 tablespoons lavender essential oil
1 cup borax
2 cups baking soda
3/4 cup sodium lauryl sulfate

Mix clay powder with lavender oil in a 2-quart container, then stir in other ingredients. Use 1 cup of mixture per load of sheets. If desired, add 1/4 teaspoon lavender oil to rinse cycle.

Wool Wash with Lanolin and Cedar

This soft soap's mission is not only cleaning; it enhances and protects fabric, too. The lanolin in the formula restores wool to some of its original luster and water repellency; cedar essential oil keeps moths away. Use this soap in the washer, on the delicate cycle with cool water. It's also great for handwashing your favorite woolens.

2 cups grated castile soap
6 cups boiling water
1 tablespoon sodium lauryl sulfate
1 teaspoon white cedar oil
1 teaspoon lanolin

Lemon and mint combine for a refreshing and sparkling clean window wash.

Put grated soap into a wide mouth 1/2-gallon jug (glass or heavy plastic). Add the boiling water and let the mixture sit for half an hour; then stir in other ingredients. Store in a capped jar. Use approximately 1/4 cup per sink load of woolens or 1 cup per automatic load.

Note: Many of the ingredients mentioned in this article can be found at specialty food stores or can be ordered from Sun Feather Natural Soap Company at www.sunsoap.com or 315-265-3648.

AUTHOR BIOGRAPHY

Sandy Maine, the founder of SunFeather Natural Soap Company and the author of four books, considers her soaps incomplete without herbs.

The healing and rejuvenating powers of herbs lend well to skin and body care.

by Mindy Green

There is no better way to pamper yourself than with the healing and rejuvenating powers of nature's original beauty aids, herbs. Since before recorded history, herbs were used in the treatment of many physical and emotional problems. The cosmetic uses of common garden herbs such as calendula (*Calendula officinalis*), lavender (*Lavandula* spp.), chamomile (*Chamaemelum nobile*) and rosemary (*Rosmarinus officinalis*) all enjoy a long history in treating a variety of complexion problems. Herbs were also used in bath preparations for stimulation or relaxation, depending on the properties of the chosen herbs. The antibacterial action of the plants helps clear acne, soothe stressed or irritated skin and generally improves the complexion. Simple preparations of the teas can be incorporated into baths or added to your favorite commercial skin care products, or better yet, into the products you make on your own.

The following recipes have suggestions for use with children, and are a great way to introduce young ones to the healing benefits of plants. If your children are old enough, they can help create these herbal products, which makes them even more special. One of my nephew's first words was "massage" as he pointed to the special oil I made for him using calendula and lavender infused in vegetable oil. It was also the same formula his mother used on her pregnant belly to prevent stretch marks, and the baby oil that was used on his diaper area.

These preparations are easy and fun to make. Enjoy the time you set aside to partake of nature's gifts and give thanks for all she provides!

Bath

The bath is a good place to start in treating your body to the enjoyment and relaxing benefits of herbs. Let's begin with a strong herbal infusion of calendula flowers that soothe any skin irritation. The stronger you make the tea, the more healing potential it will have. If your goal is just to soothe and soften the skin, you should use a weaker concentration than if you are treating hives, rash or eczema.

Calendula Herbal Bath

2 quarts water
1 cup dried calendula

Boil the water, add the herb, cover and let steep until lukewarm. Strain the mixture into the tub, but don't discard the herbs yet! Tie them up inside a thin washcloth and use this to scrub your body.

A bath oil is especially good to protect against the dryness of western regional climate. Added to the bath, the oils float on top of the water and coat your skin as you slip into the tub. It is also one of the easiest and least expensive stress-busters you can provide yourself. Light a candle, play some soothing music and soak your cares away.

Lavender Bath Oil

1 ounce herb-infused oil
(see page 55 for instructions)
25 drops lavender essential oil
(for extra fragrance and relaxation)

Shake to mix. Use one to two teaspoons per bath. For babies, mix six drops essential oil to one ounce of the infused oil and use 1/2 teaspoon. This formula may also be used as a massage or after-bath oil.

Bath salts are an easy way to soften hard water. They make water feel more slippery and make your skin feel smooth. They are easy to prepare. They make a wonderful gift!

Soothing Skin Bath Salts

1 cup borax
1/2 cup sea salt
1/2 cup baking soda
1/2 cup finely ground oatmeal
1 ounce herb-infused oil
30 drops lavender essential oil (optional)

Mix the dry ingredients together and add infused oil and essential oil, stirring well to combine. Use 1/4 to 1/2 cup bath salts per bath, added after the tub is full. Stir well to dissolve. Store the remainder in a glass jar with a tight-fitting lid and use within three months.

Body care

Is there an image more indulgent than dusting your just-bathed body with a big fluffy powder puff, soft and thick, fresh-smelling and silky to the touch? This powder is made without talc (a substance that can be harmful if inhaled) and is safe for use on feet, under the arms, and also makes a great baby powder.

Baby-Your-Body Powder

1/4 cup arrowroot (*Maranta arundinacea*)
1/4 cup cornstarch
1 tablespoon fine white clay
4 tablespoons finely ground herb (your choice)
10 drops lavender essential oil (optional)

Put the flowers through a sieve to remove any large bits. Mix all the ingredients well and apply liberally. Try to avoid creating a "cloud" with the powder, especially on babies.

Complexion

This facial scrub acts as an exfoliating cleanser, removing dead skin cells, allowing new skin to shine through. It will help reduce fine lines and leaves your skin feeling smooth and soft. If your skin is very delicate or sensitive, or if you have severe acne, do not rub vigorously with this preparation. In such cases, allow the powder to soak a bit longer with extra liquid to soften and gently apply to the face as a mask.

Facial Scrub

1 cup oatmeal
1/3 cup cornmeal
1/3 cup dried calendula or lavender

Grind the ingredients in an electric coffee grinder to a fine powder. Store in a closed container. To use the scrub, make a paste of one teaspoon scrub powder and enough water to moisten, and apply to a dampened face. GENTLY scrub face and rinse with warm water. This mixture may also be used as a mask. Use moistened teas of calendula for normal skin, chamomile for sensitive skin, or lavender for oily skin. Apply the mask and leave it on for five to 15 minutes. This powder can also be mixed with fruits and vegetables for a delightful organic beauty treatment. Possibilities include mashed strawberries or peaches, avocado,

Lavender, a favorite herb to many, is useful in treating acne, bug bites and tension.

The soothing properties of calendula make it an excellent addition to skin care remedies

banana, cucumber and carrots. If you want to be creative, try a bit of yogurt or honey for some added moisturizing benefits.

This herbal steam will open the pores, soften dirt and oxidized oils, deep clean and rehydrate the skin. This is very good for cleansing oily skin, but delicate skin types must take care with this product. If you have couperose skin (tiny broken veins), a warm compress with the tea is preferred over steaming, which could cause further damage due to the heat causing expansion of fragile capillaries.

Herbal Steam

1/2 cup calendula
1/2 cup lavender
1/2 cup rosemary
1/2 cup chamomile

Mix all the herbs together and make a strong infusion of 1/2 cup of herbs to one quart of boiling water. Strain into a bowl and make a "towel-tent" over the bowl to capture the steam. Hold your face at least 12 inches from the water and steam for three to seven minutes. Use the cooled tea to splash on the face as a final rinse after cleansing.

This herbal mask (recipe on page 57) is suitable for all skin types, but is especially good for dry or acne skin. (You may wish to leave out the vegetable oil if treating oily skin.)

Herb-Infused Cosmetic Oils

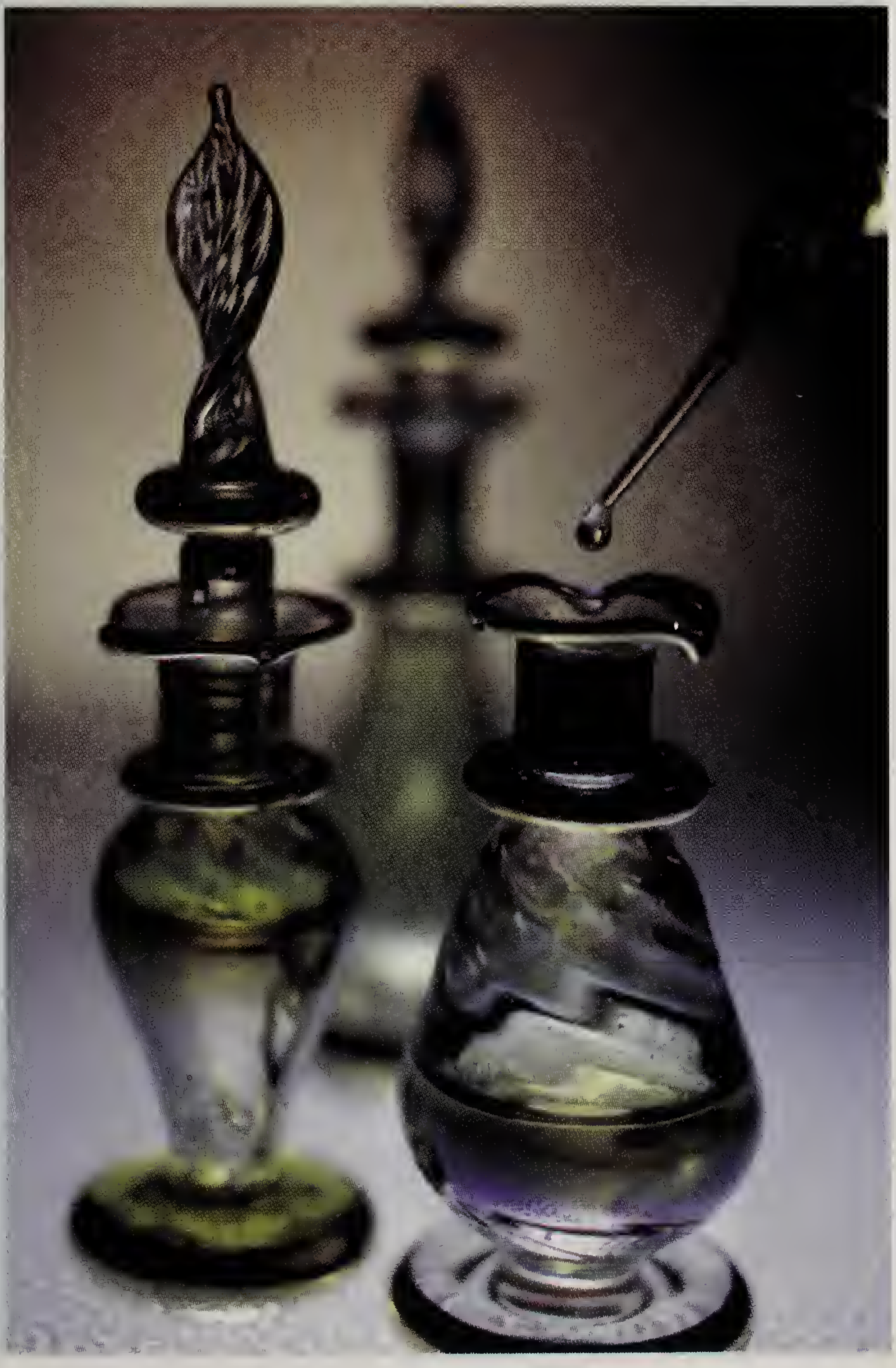
Oils made by macerating (soaking) herbs in oil are called infused oils. These herbal oils can be used for a variety of cosmetic purposes and are a perfect base for massage oils, aromatherapy perfumes or bath preparations.

Ingredients:
1/2 cup dried herbs
Hazelnut or almond oil to cover (for cosmetic applications or massage)

Coarsely grind the herbs in a blender. Place the herbs in a wide-mouth jar and add enough oil to cover. It is difficult to give exact measurements since the "fluffiness" of each herb varies. Check the mixture in a day or two; you may need to add a bit more oil since some herbs are quite absorbent. Keep in a warm place and shake daily. The ideal temperature is about 100° F, but fluctuations in temperature will not harm the oil. Your infusion can soak for one to two weeks. By this time, the oil should take on the color, aroma and healing properties of the herb.

To strain the oil, line a kitchen strainer with cheesecloth, muslin or a thin flour-sack dishcloth and place the strainer over a bowl. Put the oil/herb mixture into the strainer and let it drip for a day or two undisturbed. Most of the oil will drain out, but to get every precious drop, gather the corners of the cloth and wring out as much oil as possible. Compost the herbs and store your herbal oil infusion in the refrigerator.

The herbs discussed here may be infused together or separately. Use only dried or woody herbs with this process as the moisture in fleshy herbs will lead to bacterial growth or mold.



Joe Coca

Herbal Properties

The following herbs, in plant form and as an essential oil, are safe for everyone, young and old alike. When using an essential oil, always dilute the concentration with distilled water, a vegetable oil such as jojoba or sesame oil, alcohol or by mixing it into an unscented lotion. All of the following herbs can be used as a tea infusion in the bath (one handful per quart of water) or as a beverage (one teaspoon per cup of water).

Chamomile can be relied on to soothe stress and indigestion.

Calendula (*Calendula officinalis)* — healing of chapped, burned, irritated or wounded skin. Good for all skin types, especially babies. Soothing in the bath and suitable in the kitchen, either fresh in salads (remove petals from flower heads) or cooked in grain dishes or soups.

Chamomile (*Chamaemelum nobile*) — anti-inflammatory compounds make this useful for sensitive or thin, dry skin. This classic tension tamer makes a suitable nighttime tea for anyone with indigestion, or who has a difficult time unwinding. It is safe and pleasant tasting for children.

Eucalyptus (*Eucalyptus* spp.) — most people are familiar with the respiratory benefits provided by this common tree. To open the respiratory passages, inhale the steam produced by steeping a handful of leaves in boiling water (add a few drops of the essential oil for more effect). Eucalyptus leaves made into a sweetened tea with honey and lemon also make a palatable beverage.

Lavender (*Lavandula* spp.) — useful for acne skin or insect bites; it helps to balance oil production. Relaxing in the bath and one of the best herbs to reduce stress and tension.

Peppermint (*Mentha* x *piperita*) — the flavor of this pleasant-tasting herb is familiar to everyone. It is an effective digestive aid and a perfect beverage after a meal. Its anti-inflammatory properties can be successfully employed in the treatment of spastic colon, gas and dyspepsia. Spearmint may be substituted for children. Be extra careful with the potency of peppermint essential oil in the bath. Start with one drop and do not exceed three drops.

Rosemary (*Rosmarinus officinalis*) — great for devitalized skin that needs stimulation and regeneration. This rejuvenating herb is great in the bath and lends wonderful antibacterial action and digestive powers to any culinary dish.

Yarrow (*Achillea* spp.) — this herb is useful for every body system but is bitter as a beverage tea. As with the other herbs mentioned, the herbal infusion may be used in the bath. Yarrow, combined with elder (*Sambucus nigra*) and peppermint, is a classic diaphoretic (inducing perspiration) and is a good adjunct in treating a cold or flu. It also has anti-inflammatory properties and can help to stop bleeding from cuts.

Herbal Mask

2 teaspoons facial scrub
1/4 teaspoon vegetable oil
1 teaspoon honey
1 fresh strawberry, mashed
1 teaspoon powdered herb (your choice)
1 drop lavender essential oil (optional)

Add a few drops of water or tea to achieve the proper consistency. Apply to the face. Leave mask on for five to 15 minutes. Rinse with warm water.

Facial toners are often used after cleansing the skin and before the moisturizer. They can restore the delicate pH balance of the skin if your cleanser is alkaline, as are most soaps. They are also great to use on oily skin throughout the day if washing isn't possible. Simply apply a teaspoon to a tissue or cotton ball and wipe away excess oil. This astringent may be sprayed on, splashed on or applied with cotton pads.

Astringent Toner

1/2 cup witch hazel
1/2 cup chopped fresh or 4 tablespoons dried herb (your choice)
1 teaspoon vinegar
5 drops lavender essential oil (optional)

Soak the herbs and witch hazel together for ten days. Strain, add the vinegar and the essential oil. Shake well before each use to distribute the essential oil.

Lip Balm

1/4 cup herb-infused oil
1/4 ounce beeswax, shaved into small bits

Warm the infused herbal oil in a pan and add the beeswax. (More beeswax will create a lip balm with a firmer consistency.) Test the consistency while it is still warm by dipping a cold spoon into the mixture and letting it harden. Add more oil or beeswax as needed. Add five drops of essential oil of lavender at the end for fragrance, if desired.

Hair care

Treat your crowning glory with the pampering it deserves. I recommend this rinse for dandruff, falling hair, irritated scalp or for adding shine to hair.

Hair Rinse

1 ounce dried herb (such as rosemary)
1 tablespoon vinegar
3-5 drops rosemary essential oil (optional)

Add one ounce dried herb to one pint boiling water; steep until cool. Add the remaining ingredients. Shake well and pour over the scaip and hair after shampooing. Leave on for several minutes and rinse.

All of these products make wonderful and thoughtful gifts. You will enjoy making them, and will surprise your friends with the gift of nature, beauty and healing.

AUTHOR BIOGRAPHY

Mindy Green, an herbalist with more than 25 years experience, specializes in aromatherapy. She is an author, educator and founding member of the American Herbalist Guild. Mindy currently teaches at the Rocky Mountain Center of Botanical Studies and is Director of Education at the Herb Research Foundation in Boulder. She is the author of four books on herbal aromatherapy.

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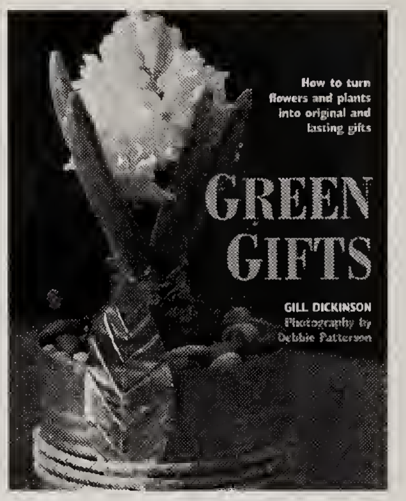
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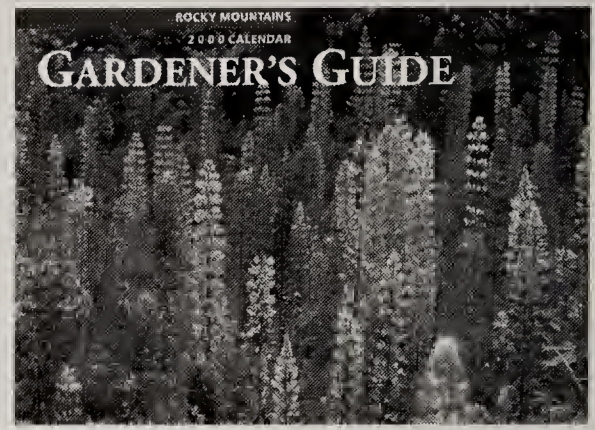
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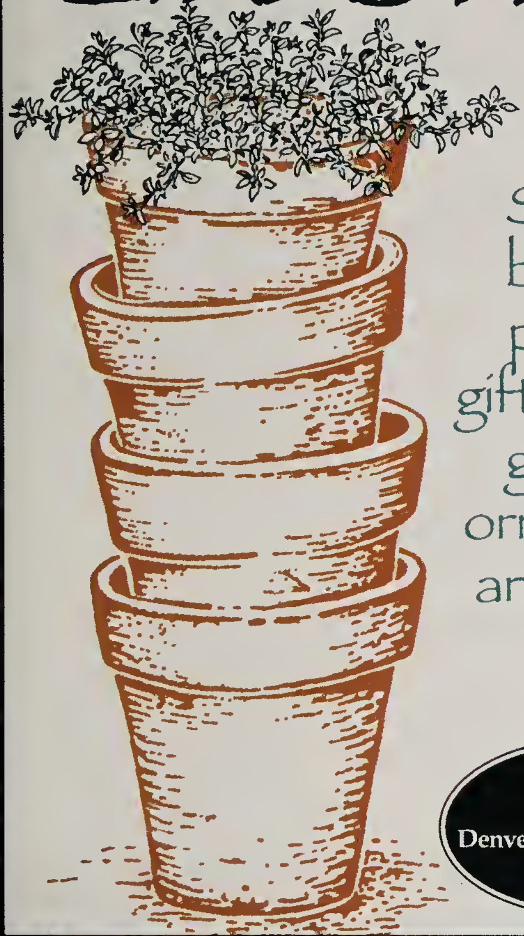

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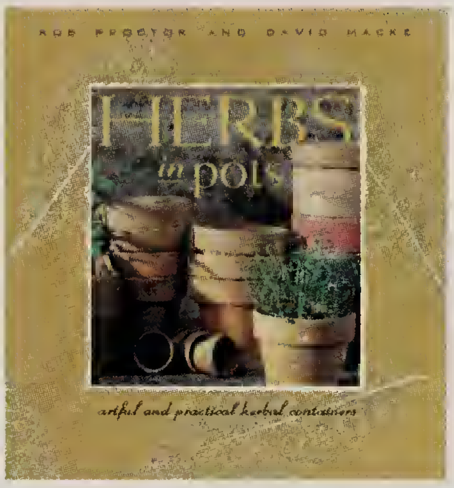

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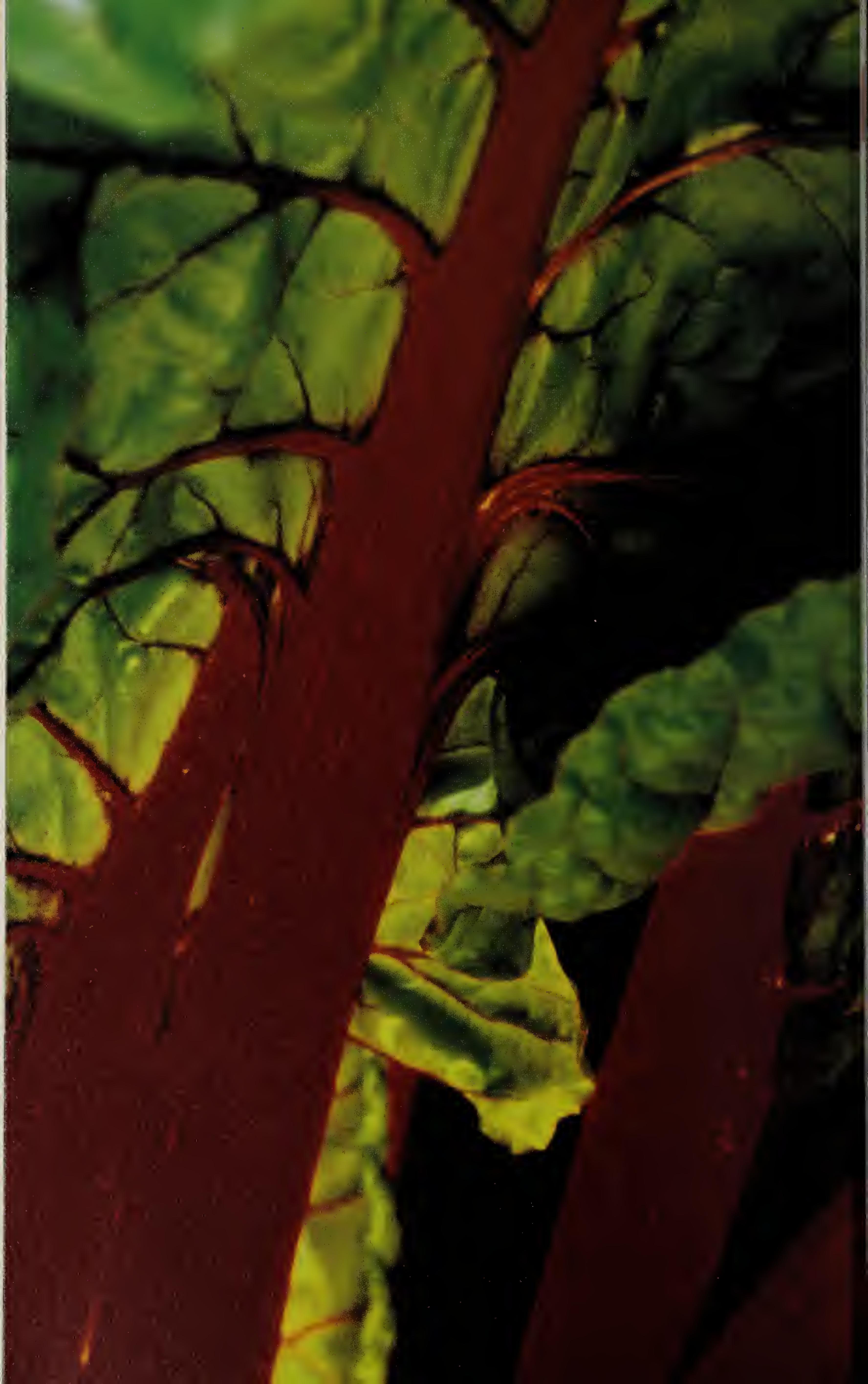
Vegetable Gardening in the Rockies

Mountain, Plain and Garden
Magazine of Denver Botanic Gardens
Volume 57, Number 1
Spring/Summer 2000



INTRODUCTION

What a wonderful and engaging edition of *Mountain Plain and Garden* this is. It has everything we all want from our gardening magazines; lots of "how-to," fascinating background, great innovative ideas, a healthy dose of compost, good writing and, at the end of the day, you can eat the product!

What particularly pleases me is that, with the exception of a far ranging and intriguing article on trends in vegetable gardening by David Whiting of Colorado State University Cooperative Extension, all of the authors are home grown and work at Denver Botanic Gardens. They exemplify the great horticultural tradition of the Gardens. These authors also highlight the newer trend towards responsible gardening. Most importantly, they reveal gardening as an excellent tool to help excite the young generation about living things and the importance of plants in their lives. Denver Botanic Gardens is an inspiring place to work as well as an inspiring place to visit and the spirit of the institution and its staff is alive in this issue.

That's enough of self-promotion. I loved reading this issue in proof and I sincerely hope you will get equal enjoyment and a wealth of great ideas from the printed copy. It encapsulates communication about plants at its best.

Brinsley Burbidge, Ph.D.
Executive Director,
Denver Botanic Gardens

Okra (Hibiscus escutlentus) *is grown for its edible ribbed pods and pale yellow flowers.*

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Front cover photos: Artichoke (*Cynara cardunculus*) by Susan Yetter / Nasturtium (*Tropaeolum majus*), Tricolor sage (*Salvia officinalis* 'Tricolor') and squash (*Cucurbita pepo*) by Rob Proctor.
Back cover photo: Pea (*Pisum sativum* 'Dwarf Grey Sugar') by Jim Havey
Inside covers: Swiss chard *(Beta vulgaris)* by Jim Havey

Denver Botanic Gardens

Denver Botanic Gardens and Chatfield Arboretum are established and maintained by Denver Botanic Gardens, Inc. for the people of the City and County of Denver and the general public in cooperation with the Denver Parks and Recreation Department. Denver Botanic Gardens is grateful for funds from the Scientific and Cultural Facilities District (SCFD) which enable the Gardens to expand services and enhance the quality of programs and exhibits.

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Jim Havey

Many of the new gardening techniques can lead to a more productive vegetable garden.

by David E. Whiting

Are you excited about the quality of produce that can be harvested from your home garden? After a long Colorado winter, I always look forward to fresh vegetables from my home garden. The semi-arid climate of this region doesn't always make gardening easy so following are some hints to make your garden more productive.

Plastic culture

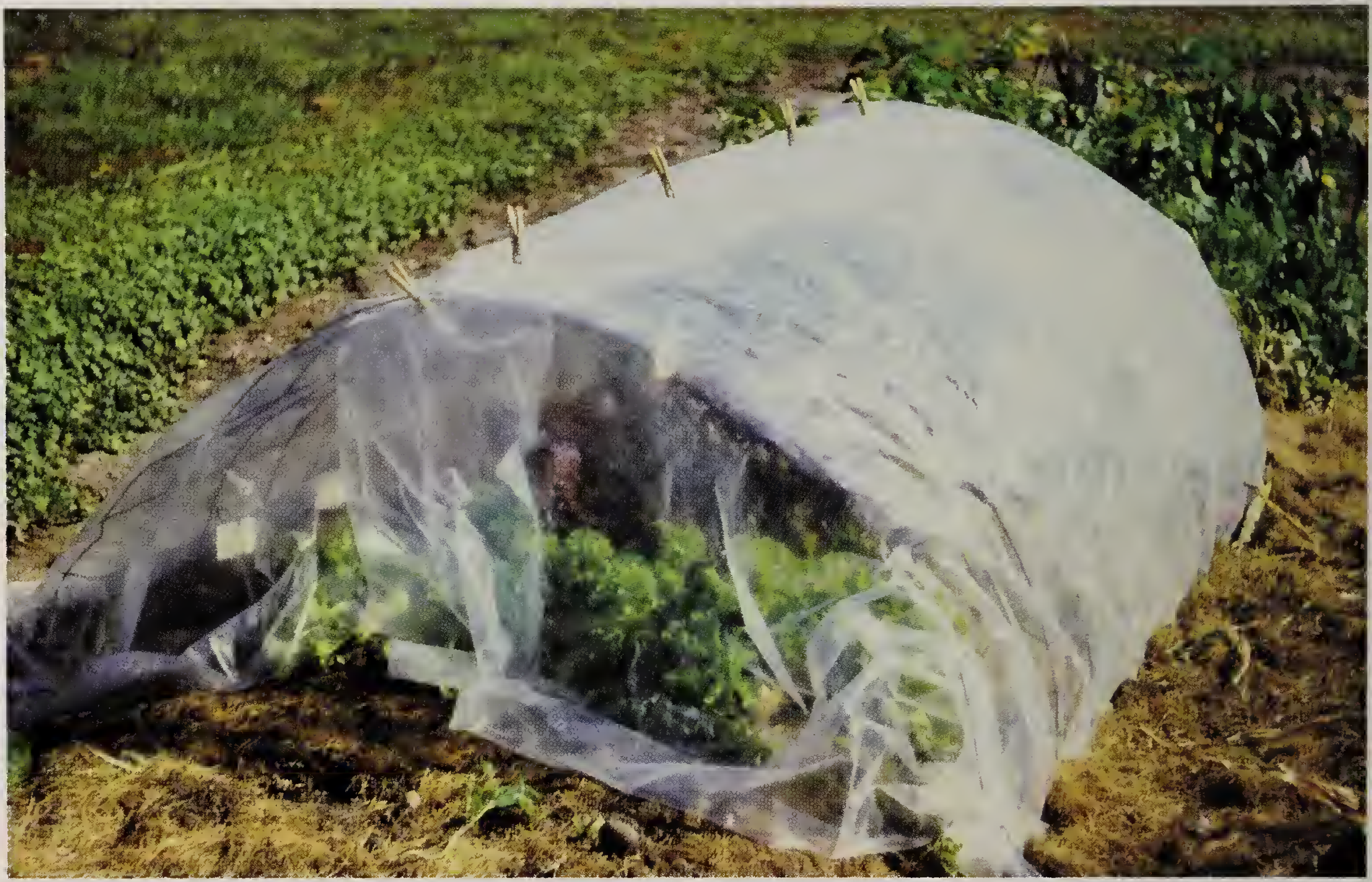
If you have driven through the Arkansas River valley in the late spring, you may have noticed the explosion in "plastic culture" in Colorado's commercial tomato, pepper and melon industry. Here, the entire industry uses plastic to bring the crops into production earlier and increase yields. Home gardeners can use these same techniques for earlier harvests, higher yields, water conservation and weed control.

Tomato, pepper, eggplant and the vine crop family (cucumber, summer and winter squash, pumpkin, cantaloupe and watermelon) thrive with a black plastic mulch to warm the soil. On the Colorado high plains, this brings the crop into production two to three weeks earlier (depending on the season's temperatures). In our higher, cooler elevations the plastic mulch will have an even greater impact on the early production of these vegetables.

Start with a three or four millimeter black plastic (polyethylene film). Lighter weight plastic breaks down too quickly in our high intensity light. Polyethylene film is readily available in garden or hardware stores in a variety of sizes, most commonly 10 by 25 feet rolls and three-foot wide rolls. Black is the standard. With the high intensity light in Colorado, red, brown or green colored plastics have not been found to increase growth as reported in some other areas. Clear plastic creates a nice greenhouse under the surface that encourages early weed growth. Landscape fabrics don't work, as they don't create the same soil heating effect.

In laying out the plastic, first prepare the soil and the irrigation system. (Drip or furrow irrigation works well.) For heating you want the plastic to touch the soil directly as much as possible. Mound the soil in the row an inch or so, laying the plastic over the slight mound and burying the edge a few inches deep all the way around. If the edges are not buried completely around, the plastic will shift in the wind. Irrigation furrows or drip irrigation tubes extend out beyond the plastic. In my raised bed garden, I staple the plastic on the side of the wood raised bed box. (If stapled on the top, the plastic will pull free in the wind.) Plant after the plastic is in place. To transplant or direct seed, simply cut a three to four inch hole and plant or seed through the hole.

The trick to this technique is that the plastic warms the soil pushing early growth of these heat-loving crops. In fact, I like to put the plastic down a few of weeks before planting to start warming the soil. In a warm soil, zucchini seeds can emerge in just two or three days! As the plants grow, they will cover the plastic and provide shade from the excessive summer heat. (If you tried to plant with black plastic mid-summer, without shade from the plant, it would be too hot.) The plastic stays on all summer conserving water and eliminating


David Whiting

A simple garden cold frame made of concrete reinforcing mesh covered with clear plastic. The cold frame is closed in anticipation of frost.

weeds. It should be removed in the fall garden clean-up.

In talking about plastic mulch, I need to clarify that this use in the vegetable garden is different than in a landscape setting. For warm season vegetables, the plastic mulch is removed each fall, allowing for the addition of organic matter to the soil. Without rock or other mulching materials on top, the plastic ripples in the wind, promoting air exchange into the soil below.

Extending the growing season with frost protection

Another benefit of the plastic culture for vegetable gardening is the use of plastic row covers that provide frost protection and warmer early season temperatures that promote crop growth. Floating row covers (available in many garden centers and catalogs) can provide a few positive degrees of frost protection. These lightweight fabrics lay directly on the plants. They also screen out some insect problems.

In the Arkansas River valley the vegetable industry uses wire hoops that hold up a clear plastic (polyethylene film) tunnel over the row. Hoops are available in some garden centers and catalogs. Depending on wind, place wire hoops two to five feet apart. Plastic must be held up off the plant, or the plant can freeze where it is touched by the plastic.

In my garden, I make a simple cold frame with concrete reinforcing mesh (a heavy gauge wire netting used in sidewalks and driveways that is sold in many hardware stores). A six-foot length makes an arch over a four-foot wide bed. The clear plastic can be held in place with clothes pins or clips and buried on the side (or stapled on the sides of the raised bed boxes).

Any plastic coverings quickly become too hot with just a few minutes of sun. They must be self-ventilating or opened daily. The plastic tunnels used by commercial growers have a ventilation hole every two feet. With my plastic coldframe, I open and close the cover morning and evening based on the weather. On cold nights it's closed. On cool days, it will be opened just an inch on top to prevent overheating. As the season warms, I may open the top but leave the plastic on the side to protect from cool winds.

This type of covering adds two to six weeks to both ends of the growing season, depending on the year. The warmer temperatures under the plastic promote more early rapid growth. Just exercise caution that it does not become too hot! In the fall and winter of 1998 and 1999, lettuce and spinach never froze under my plastic cover in Fort Collins, Colorado. One spring in St. Paul, Minnesota (average frost date of May 15th), my neighbors laughed at my plastic explosion in early March, but enjoyed the fresh broccoli, cauliflower, and cabbage harvested by late May! This type of covering can be very successful in helping gardeners at higher elevations deal with the short growing seasons and frosty summer nights.

A garden cold frame with the covering opened for a warm spring day.

David Whiting

The Walls of Water™ product provides frost protection to enable an extra early start for this tomato plant. As water changes from liquid to ice, it releases heat that protects the young plant from frost.

I've had great success with protecting tomato and zucchini plants from frost with the Walls of Water™ product when coupled with black plastic mulch to warm the soil. One spring in the Salt Lake Valley (average frost date May 10), I had ripe 'Early Girl' tomatoes by June 1!

Soil problems

Throughout the Rocky Mountain region, poor soil conditions are clearly the most limiting factor of vegetable garden success. Both sandy and clay soils need routine applications of organic matter to be most productive.

In Colorado, we're seeing a major trend toward increased use of livestock manure and livestock manure compost. While increased organic matter is a plus, the use of livestock manure has some problems. Fresh manure is a potential source of food borne pathogens, including e-coli and can also be a major source of weed seeds. Thus it is recommended that fresh manure be composted for at least one season before using it in the garden.

The use of manure and manure-based compost can also lead to salt problems. Tests by Colorado State University found that many commercially available manure and manure-based compost sources have excessive salts. The only way to determine salt levels correctly is to perform a soil test. Beans are the first to show poor germination and growth from high soil salt levels. In some gardens that have experienced heavy applications, nothing grows until the salts are leached out.

Denver Botanic Gardens

Raised beds have many advantages.

Many gardeners see raised beds as an effective method of dealing with clay soils. A primary advantage of a raised bed is that it clearly defines walkways and growing beds. Soil in the growing area is also never stepped on, which greatly reduces compaction problems.

Mulches

More and more gardeners are learning to use mulches to conserve water and control weeds. In the vegetable garden, dry grass clippings, or grass clippings underlain with newspapers make a great mulch. Apply the clippings in late spring, after crops have emerged and the soil has warmed. Cool season crops like carrots, lettuce and onions will be sweeter when using an organic mulch that cools the summer soil temperature.

Spread the newspaper in the space between plants and top the entire area with grass clippings. The grass clippings may be sprinkled right out of the lawnmower bag, as long they are applied in thin layers (only one-quarter inch thick at any one time). Add more clippings weekly, allowing the layers of fresh clipping to dry down between applications. Avoid a thick layer of fresh grass clippings at any one time, as the fresh grass will mat and smell. Do not use grass clippings from lawns treated with weed killers or insecticides.

A few layers of newspaper make a great under layer for grass clippings or wood chip mulch. It shuts out the light, stopping the growth of germinated weed seeds. Newspapers are printed with soy-based inks and are safe to use. Do not use glossy print magazine that may be printed with other types of ink. Also, do not place the newspapers more than a few sheets thick, as the high carbon content of the paper can tie-up the nitrogen needed for plant growth.

Varieties

There are tremendous differences in vegetable varieties. Early hybrids were developed for improved yields and pest resistance. Flavor became a primary consideration with the newer hybrids. Other new trends in variety work include compact plants and earlier harvest times. Some of the new seeds are rather expensive, but are generally worth the higher cost.

Hand-picking bothersome insect pests is just one of many non-chemical control methods.

Trends in pest control

Nationally, a significant shift from the standard manufactured pesticides to non-chemical control options is occurring. Floating row covers are becoming a more popular method to shield crops from insect pests. Cucumber beetles and squash bugs can be managed by handpicking or vacuuming the crown area of squash vines with a shop vacuum. It works, even if your neighbors think it's kind of strange.

A shift from the older manufactured pesticides to "organic" pesticides is also taking place. At the same time, Poison Control Centers are seeing an increase in pesticide-related problems with home gardeners, as they incorrectly assume that "organic" means without hazards. For example, insecticidal soaps can cause severe skin irritation (reddening, itching and blisters) on some individuals if the soap makes contact with skin.

Botanical insecticides (i.e., those derived from plants including Pyrethrum, Rotenone, Sabadilla and Neem) can severely aggravate human allergies and asthma. Individuals with plant-related allergies or asthma are at high risk, and for some individuals, an exposure to these "organic" insecticides can be can be life threatening.

In production agriculture over the past decade, most pesticides (insecticides, fungicides and herbicides) have changed to newer products more environmentally friendly and with fewer health risks. However, these new products rarely find their way into the home garden trade, leaving the home gardener to use many of the older, more toxic options.

Under the current farm bill, the entire pesticides industry is undergoing major evaluation. Pesticide residues tolerated on produce are being reevaluated, increasing the safety margins for children and populations segments with special dietary needs. Under the reevaluation, the number of pesticide applications on food commodities will be limited, and the interval between application to harvest may be increased. With this reevaluation it is expected that most pesticides will be dropped from home garden use, not out of health or environmental concern, but rather because manufacturers don't see the home garden market as economically significant.

David Whiting

Brassica oleracea *'Savoy Ace' cabbage is a beautiful and productive plant.*

Suggested vegetable varieties for the Rocky Mountain region

Beans
Phaseolus vulgaris ‘Blue Lake’
(bush or pole green)
Phaseolus vulgaris ‘Goldcrop’ (wax or yellow)

Beets
Beta vulgaris ‘Cylindra’
Beta vulgaris ‘Detroit Dark Red’
Beta vulgaris ‘Golden Beet’ (yellow)

Broccoli
Brassica oleracea ‘Packman’ (Italica Group)
Brassica oleracea ‘Premium Crop’ (Italica Group)

Cabbage
Brassica oleracea ‘Savoy Ace’ (Capitata Group)
Brassica oleracea ‘Ruby Ball’ (Capitata Group)

Carrots
Daurus carota ‘A-Plus hybrid’
Daurus carota ‘Pioneer hybrid’
Daurus carota ‘Scarlet Nantes’
Daurus carota ‘Thumbelina’

Cauliflower
Brassica oleracea ‘Early Snowball’
(Botrytis Group)
Brassica oleracea ‘ Ravella’ (Botrytis Group)
Brassica oleracea ‘ Self-Blanche’
(Botrytis Group)

Pickling cucumbers
Cucumis sativus ‘Bush Pickle’
Cucumis sativus ‘Calypso’
Cucumis sativus ‘Wisconsin SMR-18’

Slicing cucumbers
Cucumis sativa ‘Marketmore’
Cucumis sativa ‘Salad Bush’
Cucumis sativa ‘Sweet Slice’
Cucumis sativa ‘Sweet Success’

Eggplant
Solanum melongena ‘Dusky hybrid’
Solanum melongena ‘Ichiban’

Lettuce
Lactuca sativa ‘Buttercrunch’
Lactuca sativa ‘Green Ice’
Lactuca sativa ‘Prizehead’

Muskmelons (cantaloupe)
Cucumis melo ‘Ambrosia hybrid’
(Cantalupensis Group)
Cucumis melo ‘Earli-Dew’
(honeydew - Cantalupensis Group)
Cucumis melo ‘Rocky Sweet’
(Cantalupensis Group)

Onions
Allium cepa ‘Evergreen White Bunching’
Allium cepa ‘Sweet Sandwich’
Allium cepa ‘Walla Walla’

Peas
Pisum sativum 'Lincoln'
Pisum sativum 'Novella'
Pisum sativum 'Oregon Sugar Pod II' (edible pod)
Pisum sativum 'Sugar Daddy Stringless' (snap pea)
Pisum sativum 'Sugar Snap' (snap pea)

Hot Peppers
Capsicum 'Anaheim Chili'
Capsicum 'Jalapeno'
Capsicum 'Mexibell'

Sweet Peppers
Capsicum 'Big Bertha'
Capsicum 'Gypsy hybrid' (yellow)
Capsicum 'Sweet Banana' (yellow)
Capsicum 'Yolo Wonder'

Radish
Raphanus sativus 'Champion'
Raphanus sativus 'Easter Egg'
Raphanus sativus 'Icicle'

Daurus carota *is an easy and satisfying crop for gardeners of all ages.*

Spinach
Spinacia oleracea 'Melody'

Summer Squash
Cucurbita pepo 'Gold Rush' (yellow)
Cucurbita pepo 'Peter Pan'
Cucurbita pepo 'Sunburst'

Winter Squash
Cucurbita maxima 'Buttercup'
Cucurbita maxima 'Cream of the Crop' (acorn)
Cucurbita maxima 'Early Butternut'
Cucurbita maxima 'Sweet Mama'

Standard Sweet Corn
Zea mays 'Earlivee'
Zea mays 'Jubilee'

Sugar Enhanced Sweet Corn
Zea mays 'Miracle'
Zea mays 'Platinum Lady' (white)
Zea mays 'Sugar Buns'

Super Sweets Sweet Corn
Zea mays 'Honey n' Pearl' (bicolor)
How Sweet It Is (white)

Swiss Chard
Beta vulgaris 'Ruby Red' or 'Rhubarb'

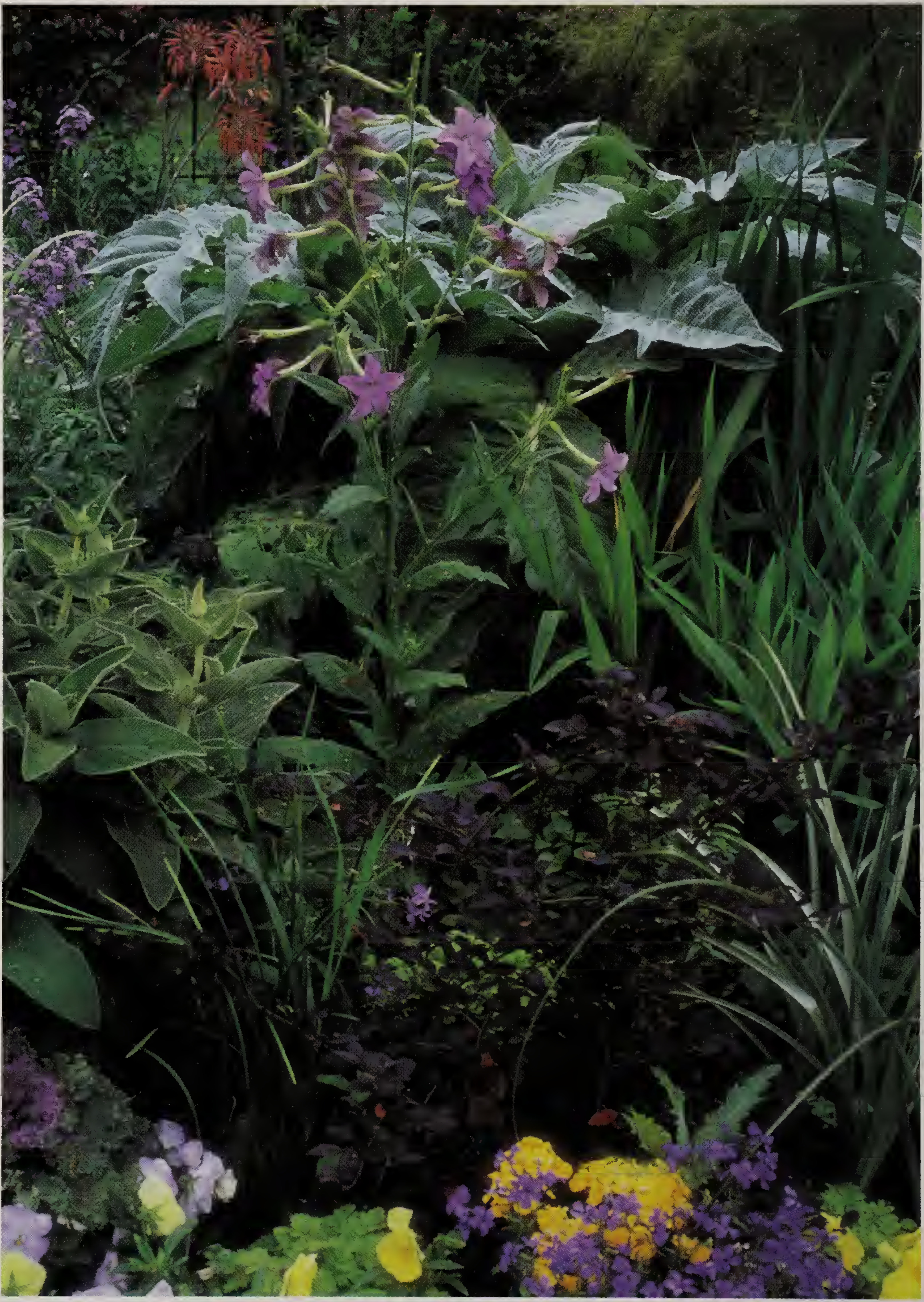
Tomato
Lycopersicon esculentum 'Celebrity'
Lycopersicon esculentum 'Early Girl'
Lycopersicon esculentum 'Roma'
Lycopersicon esculentum 'Royal Chico'
Lycopersicon esculentum 'Sweet 100' (cherry)

Watermelon
Citrullus lanatus 'Crimson Sweet'

AUTHOR BIOGRAPHY

As Extension Consumer Horticulture Specialist for the Department of Horticulture and LA at Colorado State University (CSU), David Whiting is the state coordinator of the Colorado Master Gardener Program of CSU Cooperative Extension. His teaching and research focus on home garden education, including vegetables, arboriculture and pesticide safety. Before joining CSU, David worked with Cooperative Extension at the University of Minnesota and Utah State University. He also spent eight years as home garden consultant with KSL-TV (Salt Lake City)and has degrees in horticulture from Washington State University and Utah State University.

GARDENING GURUS MERGE ART AND AGRICULTURE



The silvery-blue leaves of cardoon (Cynara cardunculus) *are the architectural anchor in this planting that includes flowering tobacco* (Nicotiana alata), *Japanese barberry* (Berberis thuribergii) *and various foliage plants.*

by Harriett McMillan

Many gardeners view the garden as an organization of spaces. There is often a distinction between the front and back exterior areas of the home. More often than not the front presents a facade of decorum while the more private back area holds the heart and soul of the gardener in charge. Here is where choice plants reside in carefully designed borders or carefree assemblies of casual charm. The seclusion of the back garden is the usual location of vegetables and associated herbs that, throughout time have been cultivated with harvest for the table in mind. As garden space becomes limited these familiar crops that provide a bounty of delicious food are being used in new and different schemes by enterprising gardeners.

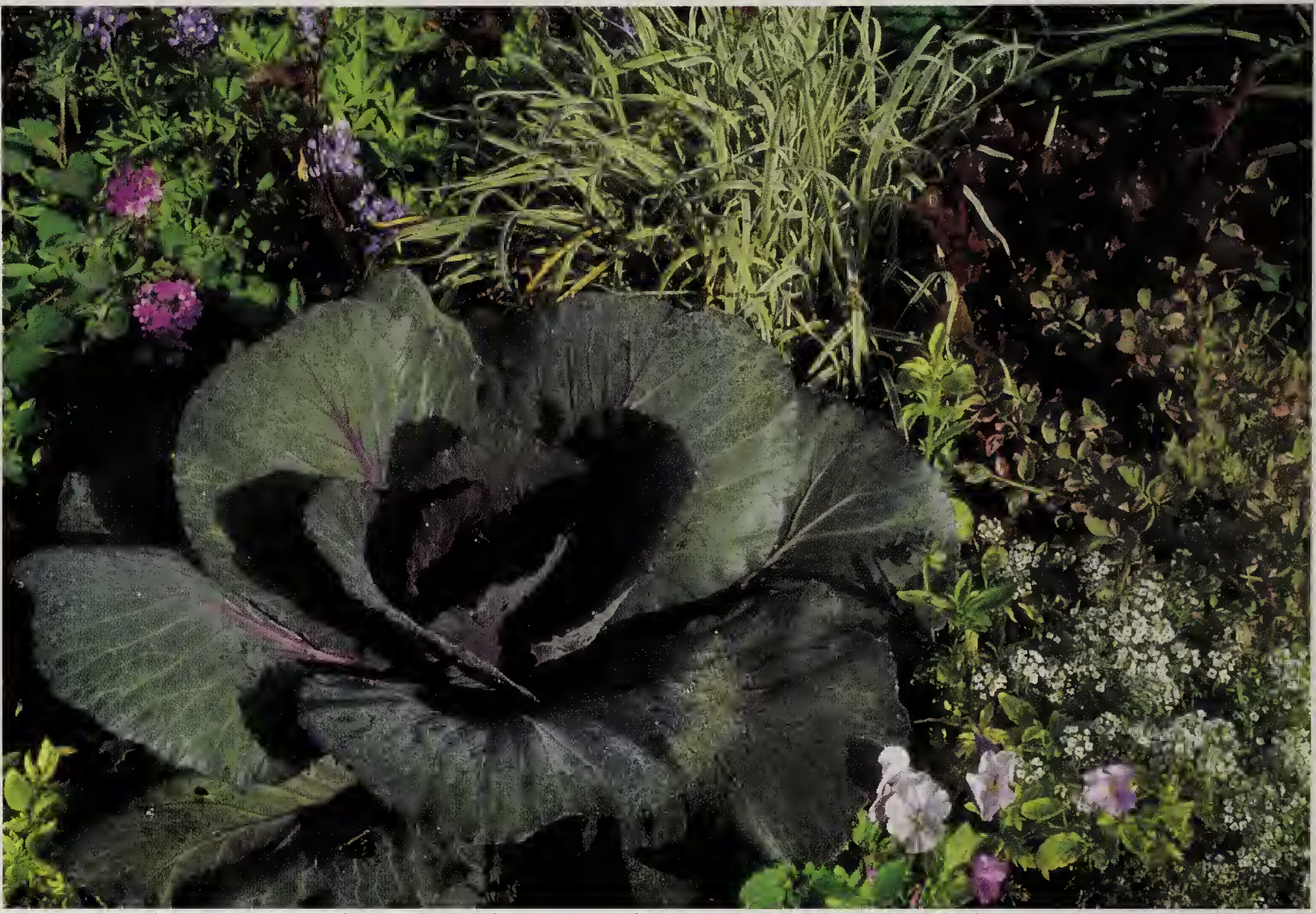
Professionals in the business of horticulture are leading the charge in freeing vegetable plants from the confines of the "vegetable garden." Rob Proctor, Director of Horticulture at Denver Botanic Gardens, and one of this region's high profile gardeners, has been using vegetables as ornamentals for years. Other proponents include authors, designers and columnists Marcia Tatroe and Tom Peace; nurseryman and columnist, Kelly Grummons and horticulturists Susan Yetter and Keith Funk. They all concur that a beautiful vegetable should be utilized for its ornamental value as well as for its culinary appeal. Likewise, they all agree that there are some challenges in this marriage of agriculture and artistry as well as advantages to be gained.

A primary concern voiced by each of these experts is that consideration must be given to the cultural needs of the plants being grown. As a rule, vegetable plants will require more frequent fertilization than most perennials. Marcia Tatroe emphasizes that regional soil conditions in some ornamental garden areas may be less than perfect for a wide range of vegetable plants. She finds her drier soil prohibiting for most vegetables that prefer a moister, richer medium in order to thrive and look their best. She does, however, call upon the colorful Swiss chard (*Beta vulgaris* ssp. *cicla*), edible kales (*Brassica napus*) and red leaf beet (*Beta vulgaris* var. *cruenta* 'McGregor's Favorite') to add their complimentary foliage to her garden. These sturdy plants hold up under her rigorous conditions.

Tom Peace

The textures of feverfew (Tanacetum parthenium) *and kale* (Brassica napus) *provide interesting contrast.*

Kelly Grummons plants his preferred edibles among perennials throughout his garden. His favorite, chosen primarily for its outstanding ornamental presence is red cabbage, *Brassica oleracea* 'Royal Red', also admired by Tom Peace. Both recommend being vigilant for cabbage loopers, a common cabbage pest which can be treated with *Bacillus thuringiensis* for control. Grummons also finds compact forms of tomatoes *Lycopersicon esculentum* 'Husky Red' and 'Husky Gold' irresistible when intermingled with traditional flowers. This



Tom Peace

Red cabbage (Brassica oleracea), *red lettuce* (Latuca sativa) *and variegated Society garlic* (Tulbaghia violacea) *create a stunning photo opportunity.*

year he is planting *Asparagus officinalis* 'Purple Passion' for the display of rich purple spears that emerge each spring in concert with bulbs and early perennials.

The small city lot gardened by Susan Yetter is home to a vast array of plants that harmonize with ornamental fervor. Here you will find peppers rubbing shoulders with ornamental grasses while the architectural presence of artichoke (*Cynara cardunculus*) adds a visual exclamation mark to the mix. She finds the vertical stems of brussel sprouts (*Brassica oleracea*) an unusual accent that is often overlooked for its somewhat eccentric ornamental quality.

All of the experts praised the edible kales for their ornamental value. Tom Peace is particularly fond of *Brassica* 'Redbor' for the purple tinged leaves that become amethyst in the summer. Expect *Brassica* 'Redbor' to tower to four feet creating a truly spectacular specimen. Red Russian kale is another of Peace's favored varieties. The large, blue scalloped leaves are reminiscent of the foliage of *Macleaya cordata* (plume poppy) and create a lush, tropical

Tom Peace

Cardoon (Cynara cardunculus), *dame's rocket* (Hesperis matronalis) *and Jupiter's beard* (Centranthus ruber).

effect. This kale also becomes quite large, a problem that he solves by harvesting the top growth for salads.

Other cool season crops on nearly everyone's list are the many varieties of chard, those with multicolored stems being a common favorite, and the dazzling array of lettuces (*Lactuca sativa*), especially the red-leaved varieties. In addition to the lettuce, mustard green *Brassica juncea* 'Osaka Purple' and mountain spinach, *Atriplex hortensis* 'Ruby Orach', are gourmet greens that are beautiful when tucked in among perennials or container combinations. Susan Yetter makes liberal use of these early season crops both in borders and containers. As they are harvested, the way is clear for a new slate of combinations for the warmer weeks to follow.

Although not vegetables, many culinary herbs were also designated as key garden players for all concerned. Both Keith Funk and Rob Proctor utilize parsley (*Petroselinum crispum*), basil (*Ocimum basilicum*), bronze fennel (*Foeniculum vulgare 'Purpureum'*), garden chives (*Allium schoenoprasum*) and garlic chives (*Allium tuberosum*) in borders as well as containers for contrasting color, texture and overall eye-appeal. Peace considers garlic chives a "must-have" plant that finds its way into many of his gardens. Its cast-iron constitution belies the pretty picture it creates in combination with just about any sun-loving perennial. Another of Peace's recommendations is garlic (*Allium sativum*). When planted in the fall, it will bloom the following summer with an intriguing spiraling habit to the flowers as they open that give the appearance of a "dance" of flowers in the garden.

Rob Proctor

Cabbage (Brassica oleracea), *Califormia poppy* (Escscholzia californica), *lettuce* (Latuca sativa) *and golden sage* (Saliva officinalis *'Aurea'*) *color-coordinate well.*

Peace continues to extol the virtues of numerous agricultural plants that he freely incorporates into designs. He describes corn (*Zea mays*), as the original ornamental grass. He relies on corn to create not only a dynamic backdrop for a border but also to act as a screen to block unattractive views and provide enclosure. Corn can soar eight to ten feet in a single season, providing a dramatic and dominant focal point with great exuberance. This is a plant that is truly ornamental in all features. The vertical form and linear foliage command attention and the textured tassle of the inflorescence extend the visual interest on through the summer.

Tom Peace

Corn (Zea mays) *adds vertical interest to chard* (Beta vulgaris), *dill* (Anethum graveolens) *and kale* (Brassica napus).

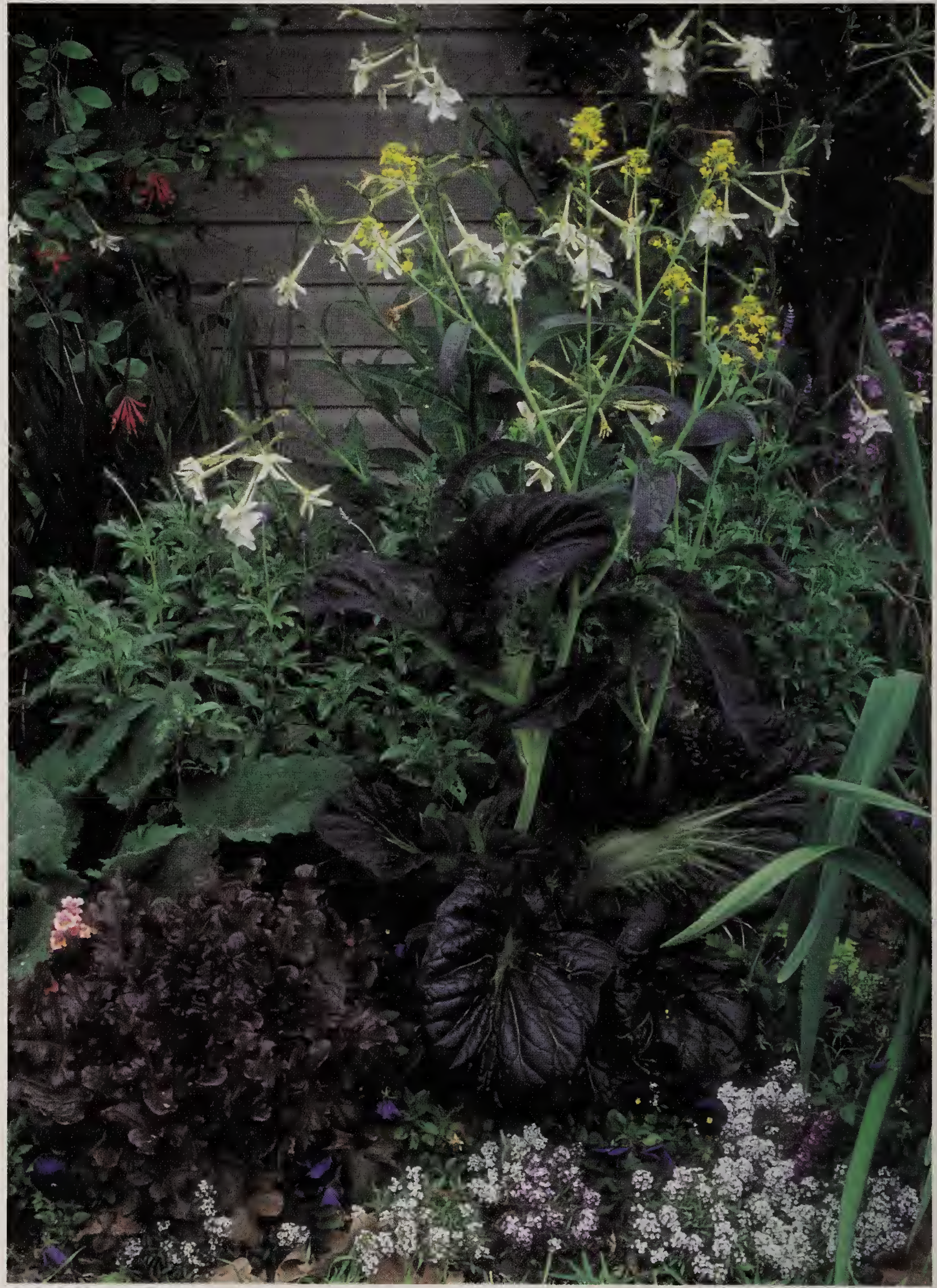
Tom Peace

Amaranth (Amaranthus hypochondriacus) *puts on a spectacular show throughout the summer season.*

Plain, old-fashioned, industrial-strength rhubarb (*Rheum* x *hybridum*) and horseradish (*Amoracia rusticana*) are two other "tried and trues" that Peace hastens to add for consideration. These extremely hardy perennial plants become increasingly large over time and add handsome foliage and interesting flowers to the garden. The heavily textured and elegant plumes of amaranth (*Amaranthus hypochondriacus*) are the ornamental feature that makes this historic agricultural crop a popular choice, not only with Peace, but everyone questioned.

Rob Proctor uses his artist's eye to appraise vegetables as worthy ornamental candidates. For foliage affect he regularly grows chard, artichoke, kale, rhubarb, lettuce, corn, squash and gourd. Prized for their fruit are eggplant, tomato, pepper, corn, squash and gourd. Proctor notes the flowers of okra, scarlet runner bean, artichoke, eggplant and squash for their diversity of color and form.

Proctor has found that the ultimate size of some vegetables will limit their usefulness, but that selection of compact forms will solve this dilemma. He has also observed that in some instances the effect he was seeking didn't quite hit the intended mark because the vegetable matured too late in the season to compliment the intended companion. Timing is also an important factor when working with the warm season crops. Rushing the season to plant eggplant



The dramatic deep color and bold texture of mustard 'Osaka Red' (Brassica juncea) *are the focus of this planting with red lettuce* (Latuca sativa) *and flowering tobacco* (Nicotiana alata).

and peppers too early often results in either stalled or stunted growth because of cool temperatures or cold soils. He advises waiting until late spring for consistent warm weather before planting.

Both Yetter and Proctor make extensive use of climbers, especially bean, pea, gourd and even smaller scale pumpkin and squash to provide quick cover for screening or to create the layered backdrop effect of leafy waves of green. Lush foliage provides the canvas for a diversity of flowers followed by the ultimate adornment of ripening fruit. Consider combinations of the "veggie vines" with morning glory, trumpet vine or clematis.

For those who are intent on keeping the vegetable area sacrosanct, Proctor proposes that the design encompass the principles that show the plants off to best advantage with one another. Consider the juxtaposition of plants and how their form, texture and color will combine for maximum eye appeal. Let artistic style count in equal importance to the utility and efficiency of regimented rows.

Keith Funk prefers to maintain a set-apart garden area specifically for vegetables. And while he often includes some vegetables in his borders, he more frequently reverses the notion and adds ornamental flowers to the kitchen garden. The method to his madness is to enliven this section of garden with additional color and texture. The advantageous by-products of this association are the attraction of a constant source of pollinators for the vegetables and a ready source of flowers for cutting without depleting the display in the borders. Some of his tried and true standards are gloriosa daisy (*Rudbeckia hirta*), dahlias (*Dahlia* cvs.), flowering tobacco (*Nicotiana* spp.), fountain grass (*Pennisetum* spp.), spider flower (*Cleome* spp.), sunflower (*Helianthus* spp.) and catmint (*Nepeta* spp.).

Bringing the beauty of the garden into the home provides a visual feast for the eye as well as bounty for the table. Proctor uses the harvest from early spring vegetable or herb crops as foliage accents in arrangements of squills, tulips and daffodils. As the season progresses the elegant fruit of eggplant, colorful tomatoes and peppers as well as unusual gourds and squash add style and verve to mixed arrangements and still-life groupings that celebrate the rich reward of the garden. He has used cut watermelon and zucchini as innovative containers for arrangements, the colorful flesh acting as the stabilizing form to hold stems in place.

What is gained from all this intermingling, you ask? All of the experts questioned agreed that respect and appreciation of the inherent beauty of plants regardless of their specific categorization is enhanced. Their creativity in design is stimulated. The diversity of plants used throughout the garden is maximized. And, all concerned professed a belief that the gardener can be creative with agricultural crops and that the added bonus for the adventure is the assurance that if your best made plans are less than perfect, you can reward yourself with the edible harvest and plan again for the following year.

Many of the plants in this article are available from the following sources:

Burpee Seeds & Plants
Warminster, PA 18974
800-888-1447
www.burpee.com

Johnny's Selected Seeds
Albion, MA
207-437-4395
www.johnnyseeds.com

Mellinger's, Inc.
North Lima, OH
216-549-9861
www.mellingers.com

Nicholls Garden Nursery
Albany, OR
541-928-9280
www.nichollsgardens.com

Park Seed
Greenwood, SC
800-845-3369
www.parkseed.com

Seeds of Change
Santa Fe, NM
1-888-762-7333
www.seedsofchange.com

Select Seeds
Union, CT
203-684-9310
www.selectseeds.com

Shepherd's Garden Seeds
Torrington, CT
860-482-3638
www.shepherdseeds.com

Stokes Seeds, Inc.
Buffalo, NY
716-695-6980
www.stokeseeds.com

Thompson & Morgan
Jackson, NJ
800-274-7333
www.thompson-morgan.com

Note: For additional information consult the two following publications available in the Helen K. Fowler Library at Denver Botanic Gardens. The library staff is happy to assist in the search for specific plant sources.

Anderson Horticultural Library Source List of Plants & Seeds
Published by the University of Minnesota
Minnesota Landscape Arboretum
Chanhassen, MN, 1996

Gardening by Mail: A Source Book
Barbara J. Barton
Tusker Press
Sebastopol, CA, 1997

Susan Yetter

Some of the more unique vegetable varieties are easiest to find through seed suppliers.

Morning glory (Ipomoea tricolor), *and Scarlet runner bean* (Phaseolus vulgaris) *combine with style on a trellis.*

AUTHOR BIOGRAPHY

As the Horticulture Information Specialist for Denver Botanic Gardens, Harriett McMillan is responsible for educating both local and national audiences about horticulture and Denver Botanic Gardens. She has more than 20 years of experience in horticulture as a teacher, nursery sales manager and is a frequent lecturer and contributing writer to *The Denver Post, The Denver Rocky Mountain News* and other publications.

Cinda Roth

The sweet smile of a happy young gardener.

by Lisa Castle

"You've *got* to taste this spinach," yells one 13 year-old across the garden. His friend trots over obediently, looks questioningly at the green leaves, and, in an act of great bravery, picks one and sticks it in his mouth.

After a few moments of intense concentration he grins, "That stuff is good!" Soon they have a crowd stuffing their faces with spinach until their teeth turn green.

My heart sings. As the Children's Program Coordinator at Denver Botanic Gardens, I live for the moments when children realize that plants are tasty, interesting, different and altogether worth noticing. Fortunately, these moments are common because children and gardening are a natural fit. Kids love to get dirty, get wet, create, experiment, watch insects, eat and be outside. In a garden that is always possible.

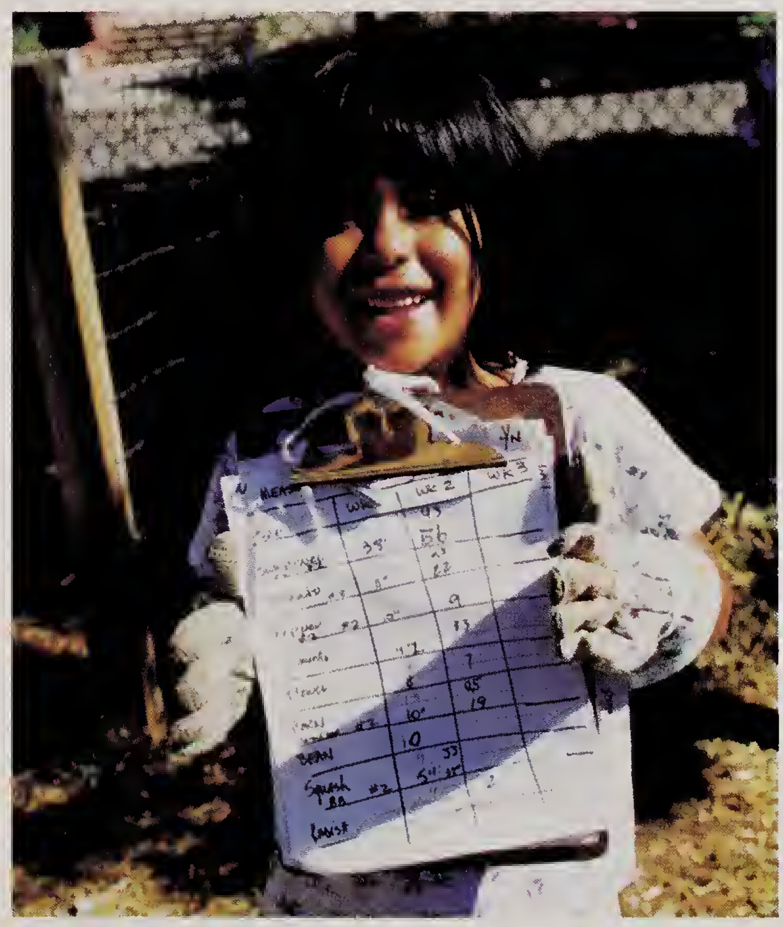
Of course, gardens can be disastrously muddy. Summers can be hot and weedy. Entire crops can wilt if unwatered during camp. September can come and go without the tomatoes ever ripening. Interest and excitement can vanish after the slugs invade the lettuce. In order for your child's gardening experience to be more fun and less horror, I have rounded-up some expert advice on why and how to successfully garden with children.

Why garden with children?

The response is always the same if you ask a youth garden coordinator why he or she started gardening with children... "Because I love to garden."

Ask why they continue to garden with children, and a long lists spews forth, accompanied by personal stories and photos of smiling faces with sunflowers and giant pumpkins. For Cinda Roth, Director of Butterfly Hope, a summer program for elementary students at Cheltenham Elementary in Denver, the chance for every student to be successful tops her list. Butterfly Hope participants also learn where their food comes from, enjoy eating their vegetables and take pride in making their neighborhood a more beautiful place.

The garden teaches environmental awareness. Children change their mindset from "all bugs are bad" to "most bugs are good." They pile all scraps on the compost pile and anxiously wait for worms.



Cinda Roth

The Butterfly Hope Program teaches math the fun way.

Roth likens children to seeds. Given the proper care, something small and inconspicuous will sprout and grow into something beautiful. Roth points to photographs of children using math skills beyond their grade level to measure the growth of sunflowers. In other pictures, students proudly teach adults about the ripening vegetables. At Butterfly Hope, children and plants grow and blossom together.

Cinda Roth

Measuring success.

Janet Kester, a teacher at the Havern Center in Littleton, started a small school garden in order to productively channel the excess energy of her 10 to 14-year-old students and make basic plant science more relevant to them. Six years later, the garden has been transformed from seven rows of salad greens to an elaborate program encompassing raised beds, square-foot gardening, grow lights, a greenhouse, baking, birdhouse making, plant propagation and a trip to a farm. Students sell gourd birdhouses, pumpkin pies, pots of pansies and houseplants they propagated from cuttings.

In Kester's eyes, the benefits of the program are multi-faceted. Not only do students gain a clear understanding of the relationships among water, light, soil, plants and food, they also develop entrepreneurial skills.

Gardening also fosters some wonderful intangibles. Self-control and patience are emphasized during the long wait from seed to harvest. Having experienced a horse running through the garden, rabbits eating the lettuce and a late freeze causing tomato panic, the students are far more empathetic to farmers who depend on crops. Plants also bring out the best in many people.

Kester has watched a child who would not open up to adults, pour out his soul to a houseplant on his desk and another find a true talent and future career in horticulture. While she recognizes that gardening is not for everyone, Kester loves to watch children who struggle with traditional

Cinda Roth

Be sure to make time for fun!

studies excel outside the classroom. "They may be the laziest thing going in the classroom, but out in the garden they are as busy as beavers."

Here at Denver Botanic Gardens we agree that gardening is good for kids' self-esteem, health and environmental awareness. It's also just plain fun. A message from my stack of thank you notes from second graders summed it up well: "My favorite thing was planting because your hands get dirty."

Well-defined paths direct young gardeners.

How to garden with children: Start small

Leave a young gardener alone with a seed catalog for an hour and you will soon hear persuasive reasons why you must grow corn and strawberries and roses and purple peppers and two kinds of apples on the same tree. This is the time where your adult-like good sense must override both your gardeners desire to try everything and your child's pleading glances. Start small and set the garden up for success. Be realistic about the amount of space you have, the amount of time everyone is willing to devote to the garden and what grows well. If, in 10 years of Colorado gardening, you have never produced a watermelon worth eating, chances are your child will not either. There is no need to confine the garden to radishes (grow quickly) and zucchini (amazingly prolific), but you should encourage young gardeners to plant the sure successes among their new experiments.

Planning for success also means planting a variety of plants. If viruses attack the marigolds or aphids infest the broccoli, have other plants to enjoy. At Butterfly Hope and in Mr. McGregor's Pick and Plant Garden at Denver Botanic Gardens, flowers and herbs planted among the vegetables ensure that there is always something to pick and enjoy. Including organic methods as part of your plan keeps the garden that much safer for children who put everything into their mouths.

Fortunately, gardening is easy. Plants want to grow. If somehow something does fail, have a digging party and try something new. Just keep "fun" in the forefront of the plan.

Janet Kester

Raised beds at Havern Center allow for vertical growth.

Mark the territory

Once you've decided upon a reasonable plan, mark the space with plenty of room for paths. Children need physical dividers between the places where they are to walk and where the plants grow. Paths also keep plants from getting unmanageable.

Amend the soil in the growing areas and do not worry about the compacted soil on the paths. Old strips of carpet prevent weeds from growing on the paths at Butterfly Hope and the IFTF Busy Bee Garden in Littleton, Havern Center uses bark mulch. My family garden uses grass clippings and in Mr. McGregor's Pick and Plant Garden chipped tree parts designate where to walk.

Cinda Roth

Children love to plant because it allows them to play in the dirt.

Leave room to dig

My gardening career started at age two when I determined that snails were a tasty addition to my diet. I soon moved on to mud pies. Many years later, about age five, I actually noticed the plants. Another five years and I learned the purpose of watering was not to make patterns on the soil. My development is not unusual. Animals, water and dirt capture children's imaginations before plants do. As a passionate gardener, this can be difficult to accept.

Jim Havey

Most bugs found in the garden are fascinating and harmless.

However, you need to keep it in mind as you plan your children's garden. Take a deep breath and leave a few feet of precious space completely unplanted. Give your child a trowel or wooden spoon and let them dig to their heart's content all season long. Harness their fascination with crawly things and digging and encourage children to help with the composting.

At Butterfly Hope, worm bins are a perennial favorite. Classes of Havern Center students have been composting and amending the garden soil for six years. Like many experienced gardeners five times their age, the 12-year-old students show as much pride in comparing their garden soil to the surrounding hard-packed clay as they do in displaying their vegetables. For many second graders on "Sprouts" tours at Denver Botanic Gardens, sticking their hands into a warm "cooking" pile of compost is a highlight of the trip. Dirt is fun. Use it to your advantage.

Grow big

Size means a lot to children. A tennis ball-sized radish, however pithy and hot it may be, is a treasure to a young gardener. Zucchini that reach the size of baseball bats are the best. Select plants that grow big. Cinda Roth recommends sunflowers that suddenly tower over children in one short season. Sunflowers also provide food for bees, birds and squirrels, making them an important link in the garden ecosystem. Corn, especially popcorn and Indian corn, hollyhocks and tall grasses are good choices for children who like to look up at plants.

Vertical growing, a practical way to save space in any garden, allows children to watch plants develop at eye level. Sticks lashed together for simple tepees to support runner beans and dipper gourds are truly a sight to behold.

Cinda Roth

Tepee structures are a creative way to accommodate the vertical growth of vining plants.

Decorate, experiment and elaborate

Every gardener knows that June, the time between planting and picking, can drag, especially if weeding is not your thing. For young gardeners, this is the time to investigate and personalize. Of course every garden needs a scarecrow. Every garden also needs row markers, perhaps ornate ones. Every year every garden needs a new logbook and map. Perhaps your garden needs a weather station and written weather reports. Perhaps it needs windsocks or wind chimes or someone to test if compost really makes the beans grow faster.

Cinda Roth

Every garden needs a scarecrow!

The garden is a creative adventure waiting to happen. Have fun in it.

How to garden without a garden

Do not despair if you have a young gardener but no garden. Small containers make can make excellent gardens and potatoes will even sprout in the back of a cupboard. Denver Botanic Gardens also offers great ways to garden without a garden. Every Saturday between Memorial

Day and Labor Day, Mr. McGregor will lead garden investigations. Often, on Sundays, storytellers will bring gardening favorites to life. Stop by and start your own gardening adventure. Who knows, you might try spinach and find you like it.

Janet Kester

The fall harvest was a big success at the Havern Center.

Rob Proctor

A net sling not only supports this young cantaloupe but looks intriguing as well.

Favorites of Young Gardeners

Tall Plants
- Corn
- Sunflowers
- Beans, cucumbers and gourds on supports

Edible Flowers
- Nasturtiums
- Johnny-Jump-Ups
- *Tagetes* 'Lemon Gem' (marigold)

Easy Flowers to Plant From Seed Among the Vegetables
- Marigolds
- Zinnias
- Cosmos

Prolific Plants
- Small pumpkins
- Cherry tomatoes
- Yellow pear tomatoes

Fast Plants
- Radishes
- Lettuce
- Spinach

Weird Plants
- Purple radishes
- Green tomatoes
- Patty pan squash
- White pumpkins
- Odd-shaped gourds
- Giant Pumpkins

Rob Proctor

The unique color of purple beans is always a favorite.

AUTHOR BIOGRAPHY

Lisa Castle, Children's Program Coordinator at Denver Botanic Gardens, loves to garden with children. Her job allows her to introduce children to the fascinating world of plants through the Sprouts, Mr. McGregor's, theme tour, activity backpack and summer programs. She also jumps at every chance to get her own hands dirty.

AN ABUNDANT ORGANIC GARDEN

by Estee Fleming

Jim Havey

A bountiful harvest from an organic home garden is especially satisfying and healthy.

Summertime isn't the same without a vegetable garden of your own. What beats a fresh salad made from the product of your hard work? Nutritionally, your body couldn't ask for anything better. Pure food from your backyard, picked fresh the day you eat it, is a gardener's reimbursement for a summer of toil.

You can grow a more beautiful and abundant garden organically with determination and the knowledge to do so. In no time, you can be snacking from your garden with a clear and healthy conscience, knowing that you are supporting the natural cycles of the earth instead of degrading them.

Organic gardening as a lifestyle choice

A good place to start in organic gardening is to look at what the term organic means. In the past decade or so "organic" has been a catch-all for discussing any type of alternative gardening techniques. Most often the term organic triggers one to think of a garden or produce that has not been sprayed with chemicals of one sort or another. In reality, it is much more than that. Organic gardening goes beyond a simple set of rules of what not to spray. It is a holistic approach to gardening, one in which the gardener recognizes a system at work in the garden greater than him or her. This system is the natural ecosystem, which is filled with biodiversity, life cycles and ecological relationships. An organic gardener works to support the balance of the garden, while gently manipulating the elements of it to achieve results.

Prior to industrial agriculture, "organic" did not exist as a term in the farm and garden world because agriculture was inherently organic. In the past, the systems and rhythms of nature were appreciated and respected and actually guided the gardener/farmer.

By the middle of the twentieth century, family farms were disappearing and large-scale food production came into popularity. This was the same time that pesticides and herbicides really made their debut. This marked a major shift in the way people thought about our food and food production. A small but dedicated group of gardeners and farmers remained devoted to the notion of natural gardening and formed a strong constituency of organic gardening advocates. Sir Albert Howard (1873-1947), author of *An Agricultural Testament*, Helen and Scott Nearing (1883-1983), founders of the Social Science Institute, and J.I. Rodale (1898-1971), founder of Rodale Press and *Organic Gardening Magazine,* were three of the strongest influences responsible for the organic gardening movement.

Today, gardeners all over the world are looking for ways to produce healthy, clean

Estee Fleming

Flowers interplanted with vegetable crops make a beautiful garden and a stable ecosystem food in environmentally sound ways. Fortunately, information on this topic is abundant, and much research is being done to improve and enhance organic gardening techniques. With our topsoil suffering from years of neglect, our seed supplies dwindling and our garden biodiversity shrinking, the movement back to organic is none too soon.

Start from the ground up

If you, too, are ready to join the movement to become a steward of the land, or have already begun and need advice on how to take it a step further, there are some fundamental concepts to understand. The place to start is with the soil. Healthy, rich organic soil is a prerequisite to successful gardening. Once you have built up your soil, all other aspects of the garden fall into place.

Soil is that from which all life grows. A depleted or worn out soil is incapable of supporting life interminably. Sustainability is a goal of organic gardening, achieving a system that can support itself over time. To have a sustainable garden we must keep our soil from becoming depleted. Vegetable gardening demands a great deal from your soil, extracting higher yields in a shorter time period. In order to accommodate this, the soil must be fed more often with rich organic material.

Organic gardening works to mimic natural ecosystems. Take the forest for example; the forest rejuvenates itself through the process of decomposition. When leaves fall, they are not raked up and hauled away, but rather break down and recycle into the ground. Through this process, nutrients are replenished, soil microorganisms are fed, and the tilth of the forest floor is improved.

Estee Fleming

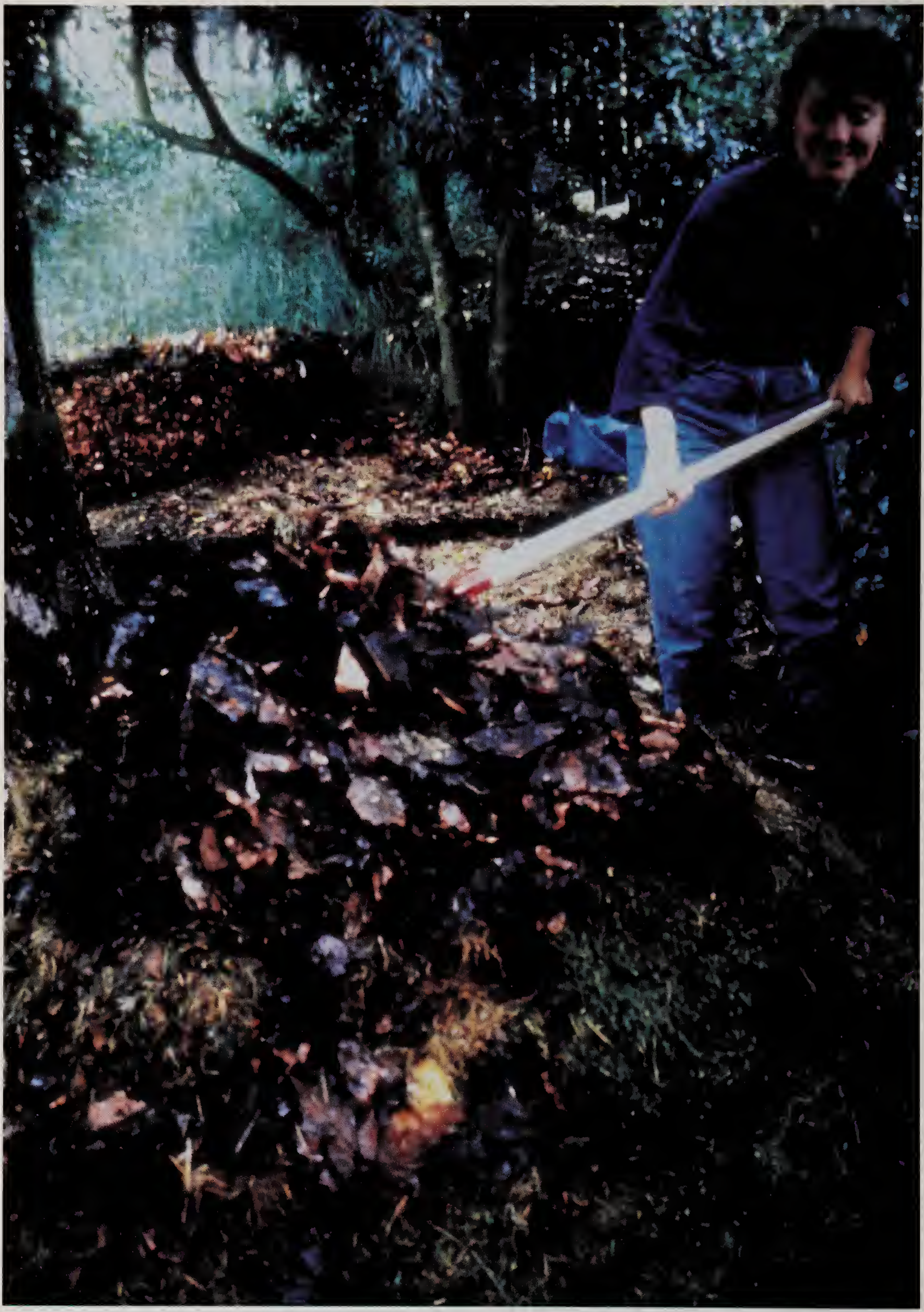
Bagged leaves are a great organic material to add to compost bin or to soil in the fall

Compost is critical

In the garden, we replenish our soil through the process known as composting. A composting system is a prerequisite to receiving organic farming certification, and the same goes for home gardeners. It is virtually impossible to be an organic gardener without composting. To be successful, the gardener must return to the garden what was taken from it.

Composting is easier than most gardeners think, once the basic parts are understood. Decomposition is a natural process, and so with composting we have nature on our side. Living in the Rocky Mountain region presents unique challenges to composting, but you can have black, rich compost in six to eight weeks once you master the regional challenges.

To begin, it is important to perceive your compost pile for what it is, a living ecosystem. Your compost needs attention, maintenance and water just like your garden vegetables do. While over time nature will do it's job of decomposition,



Estee Fleming

A "free bin" (no structure needed) compost pile must be turned regularly.

A wire compost bin provides a tidy structure.

your compost bin will be much more productive with your effort.

A compost pile begins with organic matter that fits into two categories; the nitrogenous material and the carbonaceous material. In basic terms, layering "wet" materials with "dry" materials in equal parts will suffice. Coffee grounds, vegetable scraps, green garden plants, carrot tops and manures are some prime examples of "wet" material, serving as the nitrogen sources in your pile. Leaves, dried and dead plants, newspaper and straw are some examples of "dry" materials supplying the necessary carbon to your compost.

Once you have added the necessary organic matter, the element of water is necessary. Your pile should remain consistently damp, like a rung-out sponge. In Colorado, this is one of the biggest problems gardeners confront with their compost piles. A dry pile doesn't encourage the microorganisms necessary for decomposition, and like a garden plant, the compost will not thrive in this condition.

Another fundamental aspect to a successful pile is oxygen. Without air, your pile will decompose anaerobically, which leads to a stinky, slimy mess. To achieve the dark rich soil we all dream of, turn your pile weekly in mid-summer. This helps integrate the organic plant material as well as exposing it to oxygen.

If the process of turning the pile is too energy intensive for you, there are many creative ways to achieve your desired end results. Many factory-built bins come with their own stand that can be easily turned with the crank of a handle. Whatever your style, there is a system that can work for you.

Once you master the art of decomposition, you can replenish your garden with a topdressing of compost worked into the soil in spring, and again throughout the season as it becomes available. Compost not only provides essential nutrients to your soil, but also enhances you soil's tilth, or structure. Our Colorado clay soils provide abundant minerals but can defeat an inexperienced gardener with its compacting qualities and poor drainage. A rich compost integrated into your garden will improve drainage, root growth and overall plant health over time. Enhancing your garden soil takes patience, taking years to achieve your end goal. In contrast to chemical fertilizers that are quick fixes that add nothing to soil structure, there is no comparison.

After your composting system is established, you are well on your way to becoming a successful organic gardener. For the beginner, this is the place to start. For those who have been composting religiously for years, it may be time to move up to the next phase of soil improvement.

Advanced soil pampering

Green manures, cover crops and living mulches are techniques used by organic farmers and gardeners around the world to keep the garden ecosystem strong and healthy. Green manures are crops that are planted in your garden to supplement existing soil improvement techniques such as composting. The idea is to grow a nutrient rich crop in an area of your garden where you grow annuals, vegetables or flowers. You can plant a green manure crop, like buckwheat, in the fall after garden cleanup for an early spring boost; or integrate one like clover into your crop rotations and grow them all season long. Before your green manure crop goes to seed, till it into the earth and let the ground lay for four to six weeks while the crop decomposes. This process feeds nitrogen directly into your garden beds.

Estee Fleming

A winter cover crop of ryegrass (Lolium) *will add nutrients to soil.*

An over-wintering crop doubles its benefits by protecting soil through the winter that would otherwise be exposed to elements that promote erosion and compaction. Bare soil in your garden is detrimental at any time in the season. It is prey to wind and water erosion, plus sun damage, causing a hard topsoil crust. Green manures prevent these problems before they occur.

A living mulch is another style of green manure that serves dual purposes. If the thought of minimizing your weeding appeals to you then this is a technique to try. Instead of weeds filling your path-

Healthy soil and plants provide the best defense against insect pests.

ways, plant a low growing cover crop, or a combination of them, to choke out the weeds and serve as a natural fertilizer. Hairy vetch and clover are a good combination, or you can experiment with something new. Common cover crops include alfalfa, clover, vetch, buckwheat, and rye. You can locate seeds for many of these crops at your local garden center or from most seed suppliers.

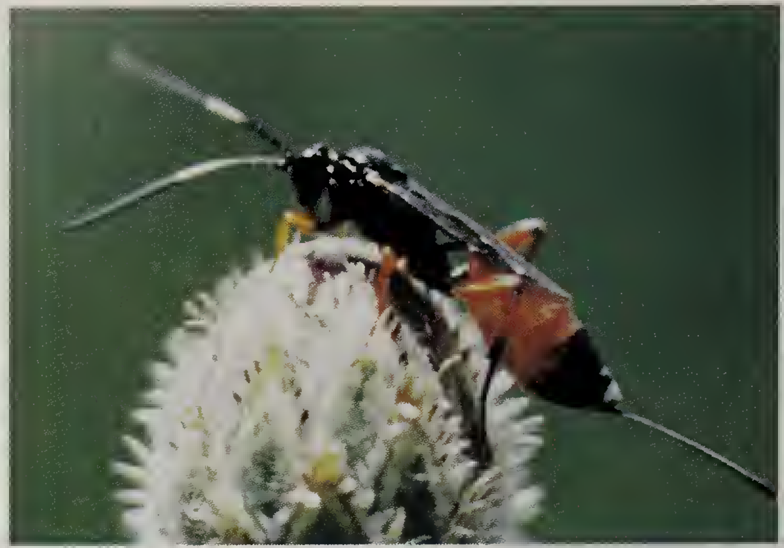
Maintaining a balanced garden ecosystem

Maintaining healthy and robust soil will improve your garden immeasurably. You can expect higher yielding crops plus prevent many of your pest problems by being proactive with your soil health. Pests become a nuisance when a garden ecosystem is out of balance. In the natural garden, insects play an important role in maintaining the cycles of life. They are particularly important in plant pollination. A problem develops when there is an overpopulation of a species.

The best defense for pest problems is preventative, which begins with healthy plants. Just as a strong human body is less susceptible to disease, so it goes for plants. A weak plant attracts invaders, and allows for a detrimental population to prosper. Healthy soil is the key to healthy plants. Aside from that, there are many secondary considerations for keeping your plants strong.

The way in which you water your plants is very important. A strong plant is formed from a good root system that goes deep and is able to absorb nutrients. A deep root system is achieved by equal and consistent watering. Light surface watering will encourage plants roots to rise to the soil surface in search of water and will result in a weak and unstable plant. When you water, water deeply and for a substantial amount of time. One long watering session is much more valuable than three or four surface showers. Efficient watering not only benefits your garden vegetables, but is also more environmentally sustainable. Our region is one where water is scarce. Practice conservation by watering early in the morning before the hot sun evaporates our precious resource, and experiment with ground watering systems to avoid unnecessary water loss as well. Many vegetable plants are sensitive to having water sit on their leaves, so ground watering will deter fungus and diseases that may result from this.

Transplanting and planting seeds at the proper time is another important factor in growing hearty vegetable plants. Seeding a crop too early will cause them to lag and may increase their rotting potential. Once a crop gets a slow start, it is often difficult for it to fully recover. Transplanting vegetable starts too early in the spring will also be detrimental, causing shock or stunted growth. Do not plant until the soil is warm and be sure to harden off your plants before permanently relocating them outside. Early spring is the most lucrative time in the garden for many pests, when plants and seedlings are new and vulnerable and the pests are awakening from their winter dormancy. Oftentimes, if a plant can make it through May with little damage it is home free for the season.


Whitney Cranshaw

Companion planting can help to attract beneficial insects like this parasitic wasp.

The important role of insects

Companion planting is another technique for maintaining balance in your garden ecosystem. Many plants have symbiotic relationships with one another and encourage growth while discouraging negative pests. There are many plants, such as pot marigold (*Calendula officinalis*), which will attract garden pests such as aphids that would otherwise attack your vegetables.

Companion planting is also valuable for attracting beneficial insects and keeping them in your garden. Beneficial insects are an aspect of organic gardening that cannot be overemphasized. The health of a garden is largely dependent on its biodiversity, which maintains a stable system. The less diversity in a garden, be it among insects, plants or soil microorganisms, the more susceptible the garden is to problems.

One of the major downfalls of pesticides is that most of them do not discriminate between the "good" and the "bad" insects, and so all are eliminated. We are seeing massive populations of pesticide resistant insects appearing, with no natural predators left to keep the system in check. Some valuable predator species you should

Denver Botanic Gardens

Consistency in gardening practices will lead to a healthy, abundant garden.

be excited to see in your garden include the lady beetle, praying mantid, green lacewing and the parasitic wasp. You can encourage these "good guys" to stick around by planting bright flowers with high pollen production.

Pests indicate imbalance

The approach to pest management in organic gardening is drastically different from that in conventional gardening that utilizes chemicals. In the organic garden, the gardener's two best tools are observation and consistency. Pest problems will most likely occur even after you have taken preventative measures with your cultural practices, like keeping your soil healthy and your garden clean.

Noticing an imbalance among your garden insects in a timely manner gives you a better chance at eliminating the problem before it gets out of hand. Make observations weekly on the state of your plants. Get intimate with your garden veggies, looking at their stems and under leaves. When your vegetable plant indicates the first signs of stress, take action quickly. The first step is to identify the problem. Once you have determined if it is a pest, a bacteria, a fungus, or a cultural problem, you can design your approach. Solutions will inevitably vary with the problems. As an organic gardener, look at your problem through the considerations of biodiversity, balance, soil health, environmental influences and cultural influences. Most likely you will come to find a solution using these principles. Consistency in all of your gardening practices will pay off immeasurably with a healthier, more abundant and more beautiful garden.

In the grand scheme of the garden, it is important to realize that insects are a part of nature. To a certain point their presence in the garden signifies a degree of health. As you become a more proficient gardener, you will come up with practices and solutions to make your gardening experience more positive.

Putting it in perspective

Gardening lies at the roots of our humanity, putting us as close to our instinctual being as possible. Practicing organic and sustainable techniques enrich that experience even further. The key to becoming a successful organic gardener is actually doing it. Journaling your experience and sharing with other gardeners will be your greatest teacher. As you continue your stewardship of the land as an organic gardener, you will experience the delight that is achieved from being a student of nature.

AUTHOR BIOGRAPHY

Estee Fleming, an avid organic gardener, has practiced organic growing on a variety of scales, from small garden plots to 20-acre organic farms. She is currently the Community Garden Coordinator at Denver Botanic Gardens, where she helps to educate people on the benefits and techniques of organic vegetable growing.

THE DOMESTICATION OF THE VEGETABLE: STEPPE BY STEPPE

by Panayoti Kelaidis

Most of the world's vegetable plants originated in high-altitude, semi-arid climates. Many of the plants that are successful in the Rocky Mountain region also flourish in other high, dry climates such as the South African highlands.

The steppe premise

Both anthropologists and agronomists have speculated at length on ways that plants might first have been domesticated. We know that in the late stages of the last ice age — probably about 12,000 years ago or so — hunter-gatherer nomads in the higher reaches of the Fertile Crescent (near the current Turkey-Iraq border) deliberately began to cultivate plots of land. If you think about it, imagine how difficult it must have been for those early farmers to find a safe, dry place to keep their selected strains of plants long enough to sow them again the following season.

The very concept of selecting and saving seed, the ability to imagine and anticipate a future crop, to take the steps to plant and cultivate, require a sophisticated understanding of temporal sequencing that can be a challenge nowadays to modern farmers and horticulturists. How many times was the next year's seed crop eaten by hungry people who couldn't wait? How did these early farmers cope with hail, drought and threats of Pleistocene megafauna? Some of us worry about bunnies nibbling carrots in our gardens, imagine a mammoth munching in your cabbage patch.

This process repeated itself again and again over the centuries — in the high dry plateau of Mexico where corn was practically invented, in the Andes with potatoes and with each vegetable crop we now take for granted. Interestingly, most of these plants seem to come from a high altitude, semi-arid climate subjected to some long period of cold dormancy. The impetus for gardening seems to be derived at least in part from stress: the need to store carbohydrates over the winter or through times of drought.

Great agronomic scientists like Vavilov in Russia and Jack Harlan in North America have observed that the plants that humanity relies upon for food have originated in just a few, relatively concentrated areas on earth. These are termed "centers of diversity" and agronomists have concentrated efforts to obtaining wild and near wild seed of agronomic plants from these regions for genetic stocks and general plant collections. These serve as a reservoir of biological diversity from which to draw — especially if food plants should be threatened with a sudden epidemic disease or insect pest.

The explosive impact that technology, farming, development and recreation are having on the frail steppe landscapes where most of our food crops originate can't be exaggerated. Maritime climates — even tropical rain forest — can only regenerate to a point in a human lifetime. But where there is little rainfall, in high altitude steppe or desert environments, the impact of overgrazing, plowing and building takes much longer to mitigate or erase and vulnerable plants in these regions are in great threat of extinction.

In recent years I have noted that more and more of the ornamentals that flourish and persist at Denver Botanic Gardens have a familiar look to them. In our extensive trials we have concentrated increasingly on Western native plants and those from similar climates. One day it struck me, vegetables! We're growing pretty vegetables! The families of plants that flourish best in our climate are the grass, daisy, bean, mint, rose, figwort, goosefoot, cress and potato families. These of course, are the dominant families of plants in all the temperate, semi-arid climates of the world: from the paramos of South America to the steppes of Western and Central Asia, the Madrean highlands of the American Southwest or the Karroo and Drakensberg veldt of South Africa.

Panayoti Kelaidis

The terrain in this area of Larimer County, Colorado is very similar to many steppe regions throughout the world.

This is hardly an accident, since vegetables were first tamed in a steppe (vast semi-arid plains) environment. The same families of plants that prevail in agronomy are those we find in our back yard in the Rockies and on the Great Plains — in practically the same proportions.

In the Rocky Mountain region, vegetable gardens have special significance because the plants they contain are a recapitulation of those in steppe climates around the world. It was on a windy steppe in the Fertile Crescent that the first artistic act of gardening took place that permitted *Homo sapiens* to rise from hunter-gatherer to civilized master of the landscape. The following are worthy examples of plants from many of the world's high, dry regions that hold the key to creating sustainable ornamental landscapes in the Rocky Mountain region as well as similar climates all over the globe.

Panayoti Kelaidis

The root of this Chinese rhubarb has many valuable medicinal properties.

The Silk Route rhubarb

Rheum palmatum

Most of us thought the Silk Route, that stretched from China through the wastes and deserts of Central Asia, was an avenue for importing precious spices and (obviously) silks from the mysterious East to dark and dingy Europe. People are surprised when they discover that the principal commodity on the romantic silk route was none other than the roots of a kind of rhubarb — *Rheum palmatum* to be exact.

This giant cousin to the common rhubarb of our gardens (*Rheum* x *hybridum*) is now a pampered centerpiece in woodland borders and bog margins in gardens everywhere. But for hundreds of years in the last millennium, the ground and powdered root of this mountain rhubarb from China was deemed one of the most powerful medicines in the European *Materia Medica.* Its power as a purgative was deemed more precious than any silks or mere spices that could be conveyed on this tortuous journey of seven thousand miles.

Today, the giant medicinal rhubarb of Western China is sold at garden centers in the Denver area. There are several varieties of this remarkable plant — the typical form has gigantic leaves — sometimes with a stem several feet long attached to a veritable elephant ear sized leaf with dramatic points. The color is usually a rich, dark green that contrasts dramatically with the typically light green ferns or silvery green foliage of plants like hostas that one might ordinarily grow in a woodland garden. The real celebration occurs several years after you plant your rhubarb. I shall never forget my shock when I saw the bloom stalk emerge and climb and climb, finally exposing the brilliant crimson flower buds peeking out of dramatic bracts of shiny stem leaves. After the plant reached some 12 feet in height, the flowers opened to reveal a soft, carmine red color.

There are two variations I have seen in gardens. I have grown a white flowered variant with leaves a much paler green in color that was almost as robust. There is also now a cultivar called *Rheum* 'Red Ace' that has gigantic leaves of a deep purple-black color and is a stunning shade garden plant. This famous rhubarb was eventually smuggled out of China by Western European entrepreneurs who knew of its invaluable digestive and purgative medicinal properties. Unfortunately, when grown away from the high, dry climate and soil of the Chinese mountains, the plant developed different chemical properties that lessened its effectiveness.

In North America, gardeners have discovered that this rhubarb performs poorly in the hot, muggy conditions of the Eastern states, and grows particularly well in the mountain states. It needs rich soil, abundant water and a spot not too hot, but with some sun. It is a permanent and dramatic feature at Denver Botanic Gardens in several gardens (including the Rock Alpine and the Drop Dead Red Border).

Panayoti Kelaidis

Allium caeruleum *produces light blue spheres of color May through June.*

The onion clan

Allium spp.

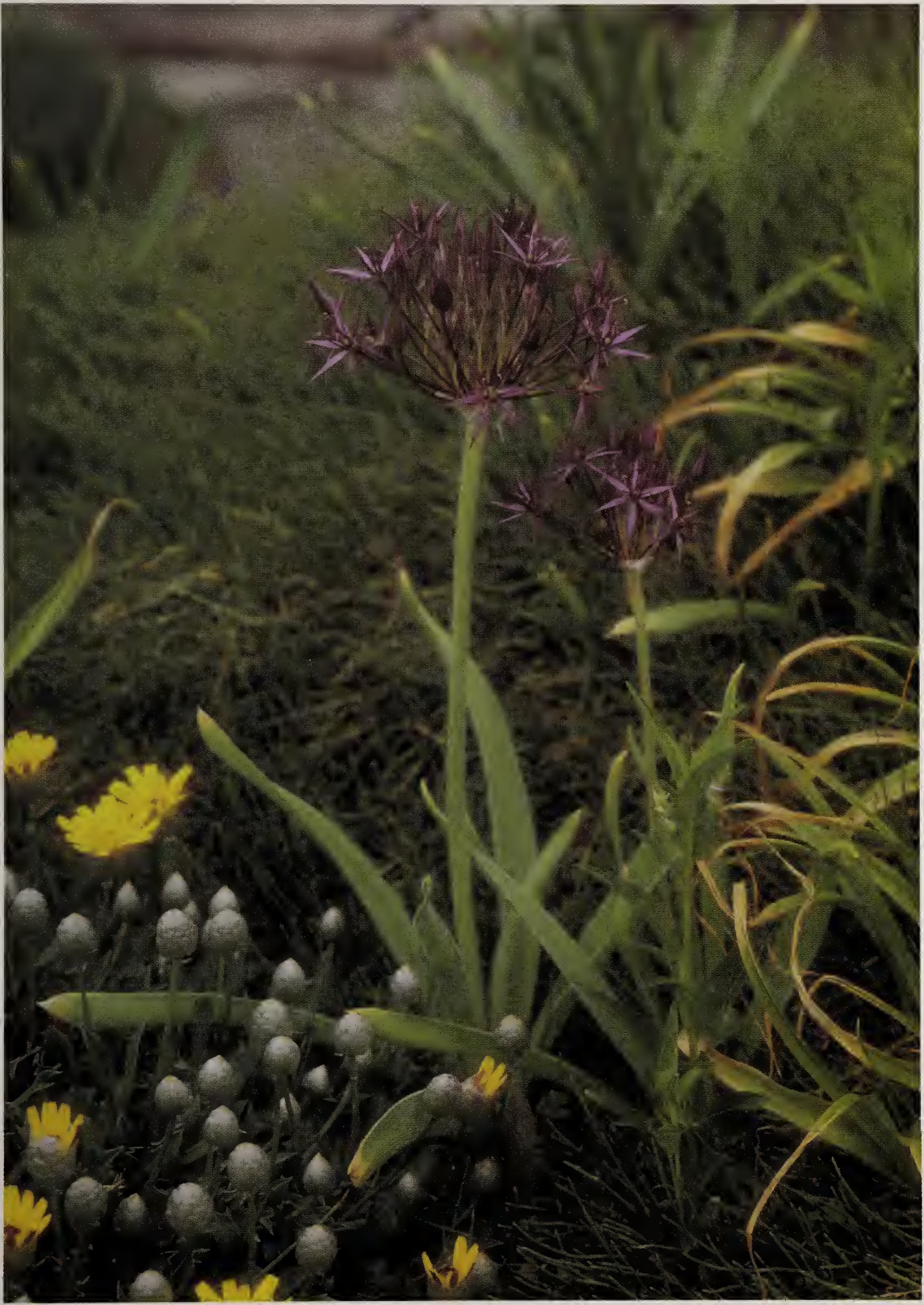
As possibly the largest genus of bulbs currently available to our gardens, ornamental onions vary greatly in flower color, season of bloom and garden merit. Some species bloom as early as April and continuously emerge into the last weeks of autumn. They generally produce clusters or balls of bloom in practically any hue of the rainbow. Most do best in well-drained loam, but there are many exacting dryland species from the American West and Central Asia that challenge the skill of any gardener.

The nodding onion, *Allium cernuum* is one of the most widespread and variable onions. It is especially beautiful and abundant in the Rocky Mountains. Here the starburst of 1/4" blossoms nod like fireworks. The flower color is usually a delicate lavender pink, though rather harsh tones have been selected on occasion. The height can vary from six inches to almost two feet in height.

Allium moly has comparatively huge bright yellow blooms in mid to late spring. This European native is said to be weedy, but has not proven so in our regional trials. This onion prefers more moisture and a bit of shade. It is available from an assortment of local or mail order nurseries. This delightful garden plant has an extraordinary history in garden literature and cultural history. Unbeknownst to most of us, the magical history of this beautiful onion is encapsulated and preserved in the expression "holy moly"—not something taken lightly or facetiously in the Middle Ages.

Possibly my favorite ornamental onion is the blue onion, *Allium caeruleum.* This is offered inexpensively through the Dutch bulb trade, although a few starts in a Colorado garden can quickly produce sheets of color. The spherical flower clusters appear in late May, and last through much of June. Each ball of cornflower-blue flowers can be two inches across. It loves ordinary garden conditions in Colorado — not too wet or shady — and is a first rate acquisition for a water smart garden.

There is one member of this infinitely diverse and variable genus *Allium* that is the perfect dinner playhouse protagonist. Chives (*Allium schoenoprassum*) not only



Panayoti Kelaidis

Allium christophii, *a member of the* Allium *genus, produces a unique bloom and plant structure.*

provide a garnish that is delicious but are also useful in a wide assortment of garden settings. The strong vertical statement of chives foliage can stand out as a specimen, an edging or in a mass planting. There are innumerable selections for height, flower color and habit.

Red orach

Atriplex hortensis 'Rubra'

In dry regions everywhere, the goosefoot family (Chenopodiaceae) can form the dominant shrub cover for hundreds of miles. This family is notorious for its tolerance of sun, heat, drought and alkaline soils. The genus *Atriplex* is particularly abundant, forming densely matted, dusty shrubs in the driest parts of the Southwestern American deserts. So, it comes as something of a surprise that there is a highly ornamental *Atriplex* from Eurasia with very large, soft leaves and an herbaceous habit.

Panayoti Kelaidis

Atriplex hortensis *(red leaved) with* Yucca neomexicana.

Orach has been grown as a pot herb in cottage vegetable gardens throughout Europe for many years. Redder leaved varieties have been selected over time, and at Denver Botanic Gardens, the dry upper meadow of the Rock Alpine Garden maintains a particularly brilliant purple-red leaved form acquired from Lauren Springer. The young seedlings of red orach germinate in winter, and grow slowly in the colder part of spring, providing dramatic contast with their dark ruby color to silvery yuccas and the greener leaved plants they grow amongst. This delightful plant provides months of color, and if you don't want it, you can eat it then and there.

Panayoti Kelaidis

Ephedra minuta *thrives in dry, sunny climates.*

Mormon tea, joint fir

Ephedra spp.

Few gardeners may have heard of "joint fir" or *Ephedra*, but most westerners know about Mormon tea, and practically everybody knows ephedrine and pseudafed. The powerful alkaloids in this ancient group of plants which is allied to conifers are not only the basis of pain compounds that are extremely important to modern medicine, but are used by countless millions of people in herbal formulation for a wide spectrum of ills. Gardeners in arid regions have come to admire the dramatic striations of the branched stems of ephedras that stand out dramatically in the winter landscape. The froth of chartreuse flowers in spring can be quite showy in a subtle way and the fleshy red fruits in summer on most species provide another season of interest.

The ephedras occur throughout the Northern Hemisphere, and down through the Andes to Patagonia in South America. They vary from a few inches high (*Ephedra regeliana* can practically form a lawn) to large shrubs in Western America or even small trees in parts of the Mediterranean. In sunny, dry climates they form very dense mounds of foliage that are texturally appealing throughout the garden year, and once established, are virtually indestructible, no matter how you treat them. Most ephedras are extremely cold hardy. This ancient and extraordinary group of plants is finally beginning to get some attention from nurseries and horticulturists in our sunny, dry climate.

Rob Proctor

Black leaf sweet potato has exploded in popularity over the last decade.

Black leaf sweet potato

Ipomoea batatas 'Blackie'

Not very many years ago I saw my first bright yellow leaf sweet potato offered by a mail order catalogue. Not long afterward, I remember seeing my first black leaf specimen. In less than a decade this has gone from rare wonder to nearly becoming a cliché in cutting edge gardens, spilling along walkways in dramatic contrast to bright red or yellow flowers, hanging from baskets, and pouring over the edges of containers.

Panayoti Kelaidis

Giant flowering kale will provide a dramatic show of blooms year after year.

Giant flowering kale

Crambe cordifolia

This plant quickly forms a mound of giant leaves to rival the biggest rhubarbs; so thoughtful placement in the landscape is essential. The real fun starts a year or two after you plant it and it produces its first spray of flowers. Imagine a baby's breath that stretches six or more feet in height and width. Every year thereafter you can expect this dramatic spectacle to repeat itself and even improve. This is a classic "see through" plant, combining artistically with almost any color, and sure to draw the attention of all your visitors.

Sea kale (*Crambe maritima*) is a bona fide garden vegetable grown for food as well as ornament. The gorgeous, sculpturesque mounds of icy blue leaves and the splendid dome of blindingly white flowers

Panayoti Kelaidis

The icy blue leaves of sea kale are both edible and beautiful.

in high spring are so appealing that I am astonished to rarely see this plant in gardens.

Denver Botanic Gardens obtained our first starts of both *Crambes* from Lauren Springer, our stellar designer/author who gardens in the foothills near Fort Collins. Both *Crambes* are allied to cabbage and true kale. Humans aren't the only creatures that like to nibble on these: their leaves are attractive to cabbage leaf caterpillars, which eventually produce the ghostly and elegant cabbage white butterfly.

Century plants

Agave spp.

Billboards and advertisements have educated Americans to the merits of century plants, although you will still find the odd holdout who thinks that tequila and mescal are made from cacti (dicots, allied to roses) rather than an agave (monocot, allied to lilies and yuccas). The species of agave utilized for alcoholic beverages are generally gigantic plants that grow best under virtually frost free conditions, and the industry

Jim Havey

Many varieties of Agave *are cold hardy in the Rocky Mountain region.*

that produces them is almost a Mexican monopoly.

Few people realize that there are a dozen or more kinds of agaves growing natively in the Southwestern United States, and most of these are proving to be winter hardy in the Denver area. These dramatic shrubby succulents make the ultimate focal point in the landscape. They also once provided an important source of food for the native peoples of the American Southwest. In early summer, before an agave rosette blooms, the rosette fattens up visibly. This represents the storage of tremendous quantities of carbohydrates necessary for producing the immense bloom stalk. At the perfect moment, just before the stalk emerges from the crown, the entire plant would be dug, the leaves would be peeled off and the hefty crown buried in a fire to roast and eat.

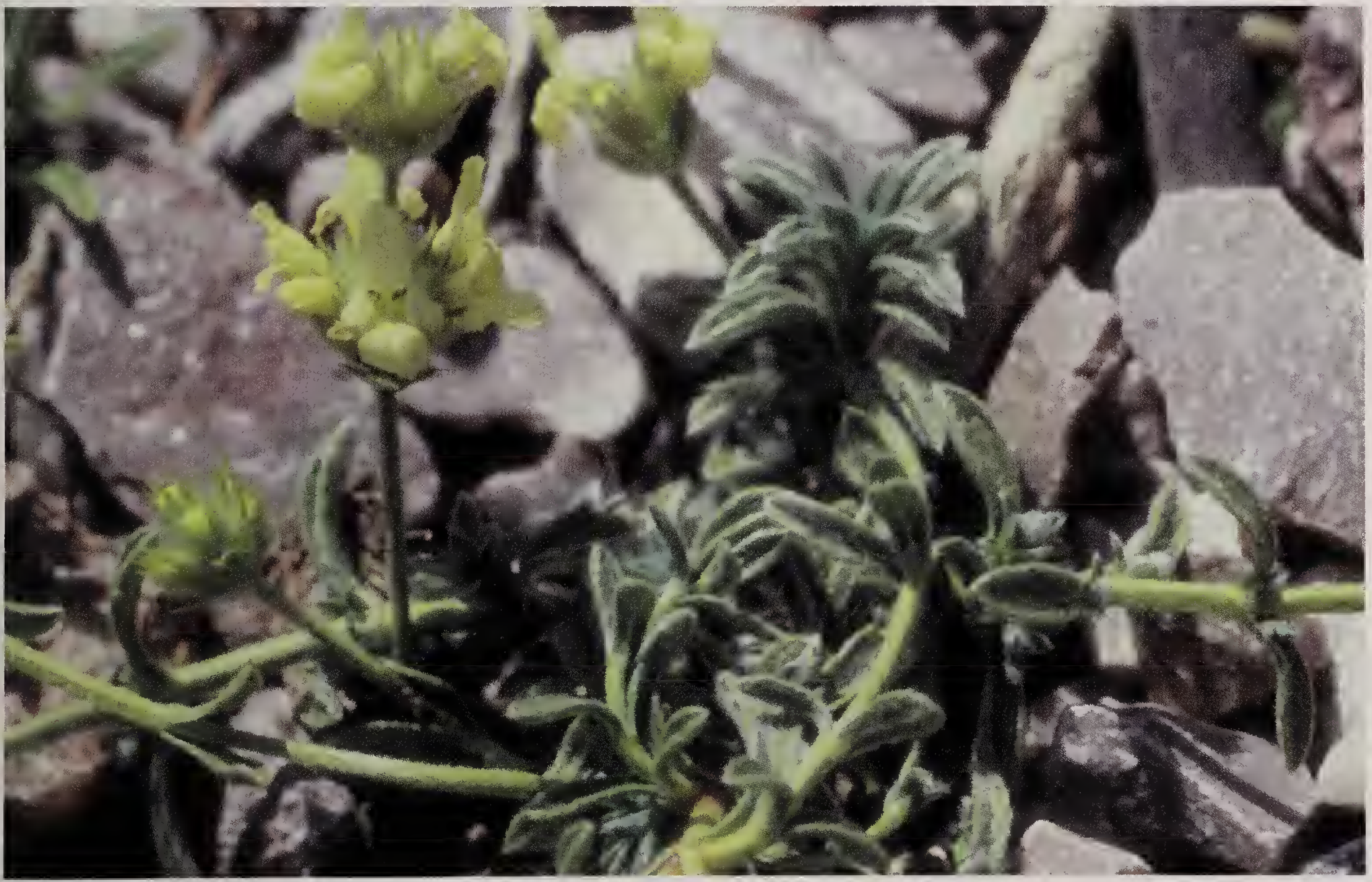
Agave neomexicana grows mainly in southern New Mexico (as the name suggests) and is most abundant on the montane slopes of the rugged mountains. It forms rosettes two feet or more across with bloom stalks of lovely yellow tubular flowers in graceful corymbs that can exceed 12 feet in height. It is hardy to the United States Department of Agriculture zone five in a sunny, well-drained soil. The flowers can be produced in less than a decade under the right conditions, not the hundred years threatened by the common name.

Agave parryi is quite similar, with wider leaves and even larger clusters of blooms. *Agave utahensis* also has many forms, all of which have proven hardy in zone five.

Mediterranean herbal tea plant

Sideritis syriaca

If you were to ask a peasant in Serbia, Bulgaria, Turkey, Greece or even Lebanon



Panayoti Kelaidis

Sideritis glascialis *is a member of the mint family.*

what their favorite herb is, I suspect nine out of ten would pronounce the local name for *Sideritis*. This immense genus of mints occupies rocky habitats all over the Mediterranean, most looking very much like the svelte, gentler lamb's ears.

The flowers on almost all species are a tall wand-like inflorescence, superficially resembling a *Stachys* or perhaps lavender. The small, tubular mint-like flowers are produced in dense verticillasters along the stem. They are almost always a cool, primrose yellow color. Dozens of species of *Sideritis* appear to be cold hardy in Denver not only in herb beds and the rock garden, but in heavier-soiled perennial beds as well. The evergreen mats of silvery foliage are distinctive and pleasing in their own right and mint products are sold in markets throughout the region as a cold remedy or just for drinking.

Rob Proctor

Ballota *sp. in combination with* Nigella damascena *(Love-in-the-mist).*

Lampwick plant

Ballota acetabulosa

I suspect that over time this remarkable genus of Mediterranean sub-shrubs will be discovered to be hardy across most of the United States. The genus strongly resembles dittany (false dittany has been used as a common name), although rather than weeping magnificently, *Ballota* is upright. The wonderfully powdery round foliage is beautiful at all times of year. The tiny pink flowers are practically swallowed up by a flannelly involucre that is shaped a bit like a Hershey's Kiss, or the very dense, compact Bells of Ireland.

My elderly Greek relatives were thrilled to find this plant in the Rock Alpine Garden, not having seen it since their childhood. The densely wooly foliage has been used to staunch wounds and as the lampwick of preference when it comes to those modest, oblong dish shaped lamps fueled with olive oil that have been used around the Mediterranean for thousands of years.

Ballota acetabulosa grows up to 18" tall with quarter-sized leaves. It has peculiar inflorescences with swollen, furry calyces that are quite decorative in their own right. *Ballota pseudodictamnus* is a smaller, smoother slightly more tender cousin.

Oregano

Origanum spp.

Origanum is a relatively small genus of mints, mostly from the Mediterranean region and best known for their culinary uses. Practically any species in the genus has some ornamental and culinary use. Many oreganos are highly local species in the Eastern Mediterranean region with very attractive bracts and floral parts. They fulfill a great promise for dry gardens once you find a spot where they can cascade and drape their weeping branches gracefully.

Origanum acutidens is a compact, mound forming perennial from Turkey with lime green bracts resembling hops. It blooms in late summer. *Origanum libanoticum* is a particularly vigorous mounding perennial with bracts suffused with maroon tints that are very striking. *Origanum rotundifolium* is another Turkish species with chartreuse bracts. It blooms from July to frost.

Panayoti Kelaidis

Origanum rotundifolium *has chartreuse bracts which bloom from July to August.*

The unquestioned gem of the genus is *Origanum dictamnus*, the classic dittany of Crete which has become quite rare on its native island. It has been thought to be very tender in non-Mediterranean climates, although we have had a number of plants come back several winters in the Rock Alpine Garden. This looks somewhat like other ornamental oreganos, only the entire plant looks to have been dipped in flour. It is worth no end of trouble to find a well-drained, sunny spot where this can settle down and luxuriate perennially.

Aloe

Aloe ecklonis

Everyone knows the familiar *Aloe vera* that has spawned a veritable industry of herbal applications. Few people know that there are a number of aloes (many of which closely resemble the classic aloe of unguents and sunrooms) that climb to lofty elevations in the high, cold mountains of South Africa. The hardiest and most variable of these is *Aloe ecklonis*, which resembles a clump forming version of *Aloe vera*, only with short stems which are a foot or so tall. It blooms in spring with bell-shaped orange, yellow or nearly scarlet flowers.

This has been the first species of aloe to survive a winter outdoors in Colorado. It goes completely dormant in the winter season and reemerges from a stout taproot in the late spring.

Panayoti Kelaidis

Aloe ecklonis *as found in the Kingdom of Lesotho, South Africa.*

Central Asian herbal tea

Ziziphora

This species is in the mint family and is abundant and widespread throughout the uplands of Eastern and Central Asia. The plants have intensely aromatic leaves that make a refreshing brew enjoyed by millions of people.

Ziziphora is closely allied to thymes, and like thymes they are intensely attractive to both bees and people. The leaves are larger, and the flower heads more substantial and showier than most thymes — resembling rather more the coyote mints of the Western United States (*Monardella* spp.).

The two species that I have grown, *Ziziphora tenuior* and *Ziziphora capitata*, seem to occur as slender annuals that self sow widely to make pools of purple color in late spring. Each plant may only be four to seven inches tall, with attractive, deltoid, clasping leaves that form a ruff beneath the nearly circular clusters of minty flowers.

Panayoti Kelaidis

Ziziphora pamiroalaica *in the Rock Alpine Garden at Denver Botanic Gardens.*

The forms that are most apt to work in a xeriscape or rock garden are the mat-forming species with rounded leaves and ball-like inflorescences through the summer season. Those that have already been introduced include *Ziziphora clinopodioides* and *Ziziphora pamiroalaica*, which are both very attractive plants in a dry garden.

Summary

The vegetable garden doesn't just provide humanity with the fuel that sustains our bodies. It can also be viewed as the living symbol of the dawning of higher civilization. Vegetable gardens represent an unbroken tradition of man's interdependence with plants. They are a vessel, an instrument upon which we continually play new and fresh tunes. By all means, seek out and grow vegetables, but also look for their ornamental cousins and you can have a viable, low water, low maintenance landscape that feeds not just your body but your artistic sensibility. They are a living link to our rich agronomic heritage.

AUTHOR BIOGRAPHY

Panayoti Kelaidis is Curator of Plant Collections at Denver Botanic Gardens. Best known to members as creator of plantings in the Rock Alpine Garden, he is charged with procuring cutting edge plants for the Gardens current transformation. He has administered Plant Select® on behalf of the gardens for the last 5 years.

AGRICULTURE OF THE AMERICAN INDIANS

by Margaret Foderaro

Jim Havey

Zea mays, or corn, was a food staple for many of the American Indian tribes.

Vanessa Tatsch

The Ancestral Puebloans often ate weedy plants like Amaranthus *spp.*

American Indians, including the Ancestral Puebloans, Hopi, Navajo and Zuni, have been gathering food and growing vegetables in the Four Corners region for hundreds of years. This region receives between 10 and 18 inches of rain annually, depending on elevation, so American Indians were forced to identify gardening techniques and plant varieties that could withstand the windy, semi-arid to arid climate.

Around 2000 B.C., life in the Southwest began to gradually change from a hunting, gathering and nomadic lifestyle. Experimentation with agriculture, especially of corn and squash from Mexico, enabled more tribes to settle in one location. Agriculture became increasingly important as populations increased and as the peoples became better adapted to the land, new and different plants were discovered and incorporated into their diets.

Most of the tribes in the Southwest now practice large-scale farming. Yet, there are families that still practice the old customs of using all plants, wild and cultivated, for food.

Ancestral Puebloans

Ancestral Puebloans inhabited the Four Corners region, including present day national parks Chaco Canyon in New Mexico and Mesa Verde in Colorado, between A.D. 500 through A.D. 1400. At Chaco Canyon, annual rainfall is less than nine inches. These people adapted to their conditions by devising a system to retain any water that came their way. Dams were

Jim Havey

Beans were a popular crop among many American Indian tribes because of their nutritional value and the fact that they grow quickly and easily.

built across canyons to divert the water through stone-lined canals to their terraced gardens. Plants that were grown by the Chacoans included corn (*Zea mays*), squash (*Cucurbita* spp.), and to a lesser extent, beans (*Phaseolus* spp.). When their crops failed to yield a harvest, they relied on wild plants such as Indian ricegrass (*Achnatherum hymenoides*) and globe mallow (*Sphaeralcea* spp.). To supplement their diet, cactus fruits and pads (*Opuntia* spp.), yucca pods (*Yucca* spp.) and piñon nuts (*Pinus edulis*) were eaten. Weedy plants like tansy mustard (*Descurainia pinnata*), amaranth (*Amaranthus* spp.), purslane (*Portulaca* spp.) and goosefoot (*Chenopodium* spp.) often invaded their gardens but were yet another source for food.

Mesa Verde, which receives twice as much moisture as Chaco Canyon, is a thousand feet higher in elevation and the vegetation, which includes woody plants, differs greatly. As with the residents of Chaco Canyon, corn, squash and bean were important crops for the people at Mesa Verde. They, too, practiced water conservation by digging out reservoirs and ditches. If wild plants like beeplant (*Cleome serrulata*), amaranth (*Amaranthus* spp.), goosefoot (*Chenopodium* spp.) and purslane (*Portulaca* spp.) invaded their garden plots, they were also used for food. Other food plants at Mesa Verde included Gambel oak (*Quercus gambelii*) and buffaloberry (*Shepherdia* spp.).

Jim Havey

The Spanish introduced chili peppers to the Hopi in the mid-1500's.

Where to purchase Four Corners crop seeds

by Susan Eubank

Native Seeds/SEARCH (NS/S) is an organization in Tucson, Arizona whose mission is to "conserve the traditional crops, seeds and farming methods that have sustained native peoples throughout the southwestern U.S. and northern Mexico..." In order to meet this mission, one of the tasks the organization has concentrated on is collecting and preserving seeds from many indigenous peoples of the Southwest. Since 1983, 250 collections from different locations and of different crops have been received from the Navajo, Hopi, Jicarilla Apache and Paiute tribes of the Four Corners region.

Native Seeds/SEARCH has a catalog that lists about 300 varieties of crops from throughout the southwest. Many Hopi and some Navajo and Paiute varieties are for sale in the catalog. The catalog is not comprehensive to all of the collections, as not all plants produce enough seeds to sell. In order to remedy that situation, Native Seeds/SEARCH has purchased a 60-acre farm. There, these collections will be grown and preserved through that regeneration. This is a complex endeavor, because each variety has to be carefully monitored to not hybridize with its neighbor and to ensure that the next generation is unchanged from the current generation.

To order the catalog contact Native Seeds/SEARCH at:
526 N. 4th Avenue
Tucson, AZ 85705
(520)622-5561
http:www.nativeseeds.org
nss@azstarnet.com

Native Seeds/SEARCH is also a membership organization. A $25 a year membership includes the seed catalog, a newsletter and a 10% discount on purchases and workshops.

Hopi

Hopi are direct descendants of the Ancestral Puebloans of Mesa Verde and have lived in the area for hundreds of years since about A.D. 1200. In fact, a village on the Hopi Third Mesa, Oraibi, has been continuously occupied since that time and has the great distinction of being the oldest town in the United States.

Between the Hopi mesas, sand has accumulated over thousands of years. Water is absorbed into this sand and deep-rooted plants were planted to reach the water below. Dams were built to slow water from summer rainstorms and to divert the water to various locations. Because of the unpredictability of moisture, many Hopi today still store a year's supply of corn as did their ancestors.

Hopi grew corn, bean, gourd (*Lagenaria siceraria*) and cotton (*Gossypium* spp.). When the Spanish arrived in the Four Corners region in 1540, they introduced lima bean (*Phaseolus lunatus*), chile pepper (*Capsicum* spp.), onion (*Allium* spp.), watermelon (*Citrullus lanatus*) and the peach tree (*Prunus* spp.). Often, these plants were stunted in growth because of harsh winds and little moisture. Other plants such as amaranth, wild dock (*Rumex hymenosepalus*), beeplant and wild tobacco (*Nicotiana* spp.), which are considered weedy or wild plants, were encouraged to grow alongside the corn and bean crop plants.

The Zuni waffle garden in the Native Peoples Garden at Denver Botanic Gardens is a garden designed to collect as much rainfall as possible.

Navajo

Navajo are thought to be descendants of peoples who came through the Bering Strait 12 to 14-thousand years ago. The Navajo eventually migrated to northeastern New Mexico long before the Spanish, who settled in that area in 1540. By 1750, the Navajo people had settled into Canyon de Chelly in Arizona where they still reside today.

When the Navajo first arrived in this area they were plant gathers and nomadic hunters. The Navajo also planted small crops of corn, squash and bean, which they may have learned about from the Pueblo Indians. The Spanish introduced the Navajo to livestock, in particular, sheep. The Navajo tended their sheep and used their wool for weaving intricate rugs and blankets.

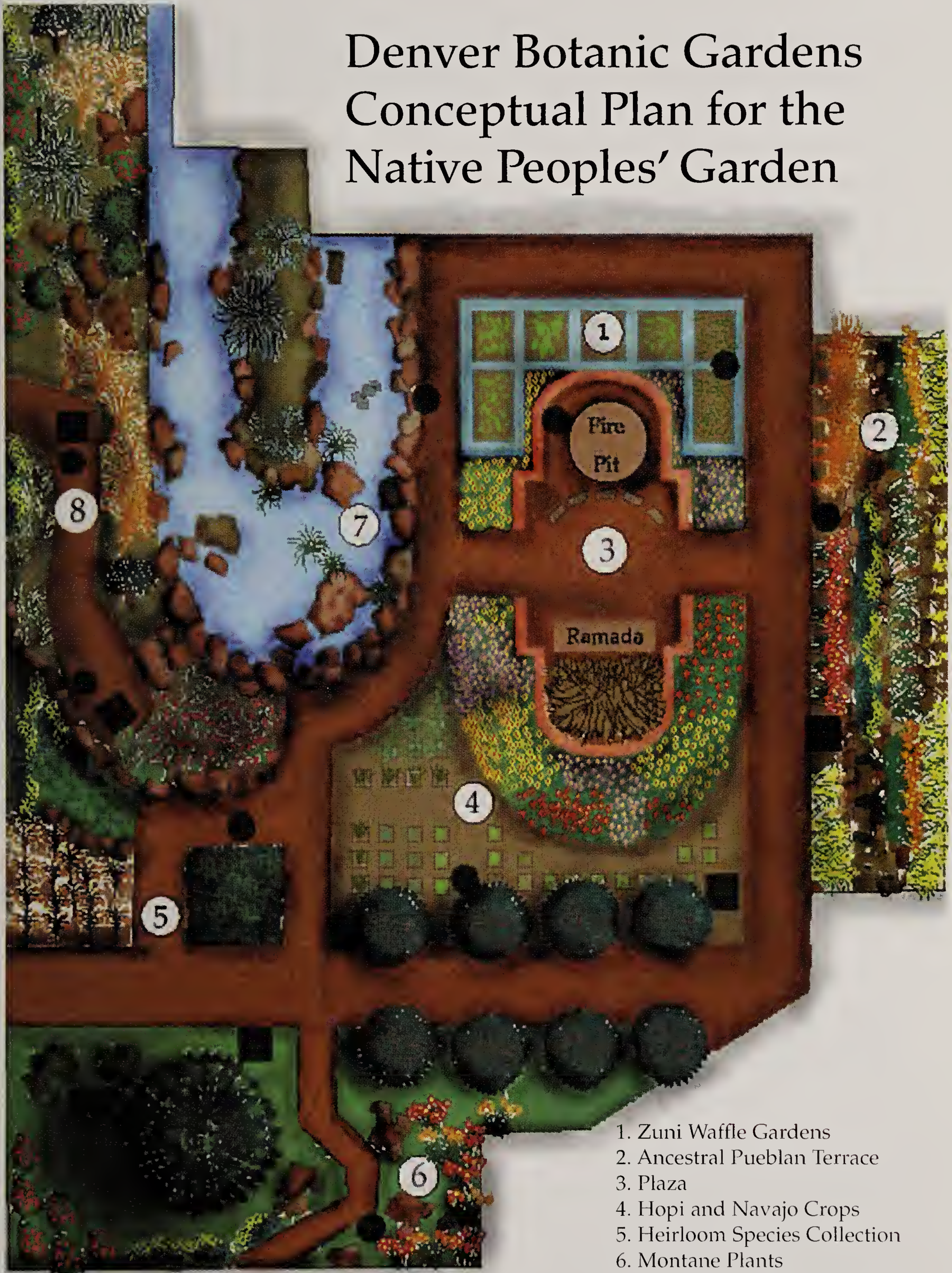
Zuni

The Zuni are descendants of the Bastekmaker III (A.D. 450) and Pueblo I (A.D. 700) people. Since A.D. 700, the Zuni occupied, and still occupy, an area in western New Mexico near the Arizona border. Moisture is minimal here, so the Zuni devised indentations in the soil to gather rainfall. These indentations are called waffle gardens because they resemble a waffle grid.

Corn, bean and squash were grown in these waffle gardens. Wild plants like amaranth, purslane and Indian tea (*Thelesperma megapotamicum*) were encouraged to grow with the other plants. At times the wild plants were gathered instead.

The peoples mentioned here still live in the areas in the Four Corners region. Some continue to practice the old traditions while others mix the old with modern technology.

Denver Botanic Gardens Conceptual Plan for the Native Peoples' Garden



1. Zuni Waffle Gardens
2. Ancestral Pueblan Terrace
3. Plaza
4. Hopi and Navajo Crops
5. Heirloom Species Collection
6. Montane Plants
7. Streambed with Native Aquatics
8. Ethno Botanic Plants

■ Interpretive Station
Signage and audio

● Demonstration Area

A view to the past at Denver Botanic Gardens

In the early 1980's, Denver Botanic Gardens created a pre-Columbian garden that featured plants used by Aztec, Inca, Mayan and Southwestern American Indians. In the summer of 2000, Denver Botanic Gardens plans to introduce a new garden in this area that will focus on plants that were and still are used by the American Indians of the Four Corners. This garden will be a permanent garden at Denver Botanic Gardens and will reflect the use of plants that are adaptable to the semi-arid conditions of the Rocky Mountain region.

The garden has four specific areas: a plaza, a cultivated area for vegetables, an aquatic plant pond and an ethnobotanic area. The plaza will accommodate Denver Botanic Gardens' events and the cultivated area will display different types of dryland farming. The ethnobotanic section, featuring plants that were used for foods, dyes, medicines, textiles, tools, and utensils, will be located west and south of the pond. When transformed with rocks, the current cement pond will mimic a river in the Southwest with many native aquatic plants used for food and baskets.

Denver Botanic Gardens has applied for a grant through The National Endowment for the Humanities, a federal agency, and the Scientific and Cultural Facilities District, a local agency, to assist with funding for this garden. An advisory committee, consisting of 10 people with various specialties, has been organized to assist the staff in developing this garden so it will represent the American Indians of the Four Corners region and the plants that have been used and are currently being used.

AUTHOR BIOGRAPHY

Margaret Foderaro holds a Bachelor of Science degree in Biology and Chemistry from the University of Southern Colorado and a Master's degree in Environmental and Plant Biology from Ohio University. She is currently charged with the development of a new garden at Denver Botanic Gardens that will focus on plants that were and still are used by the American Indians of the Four Corners.

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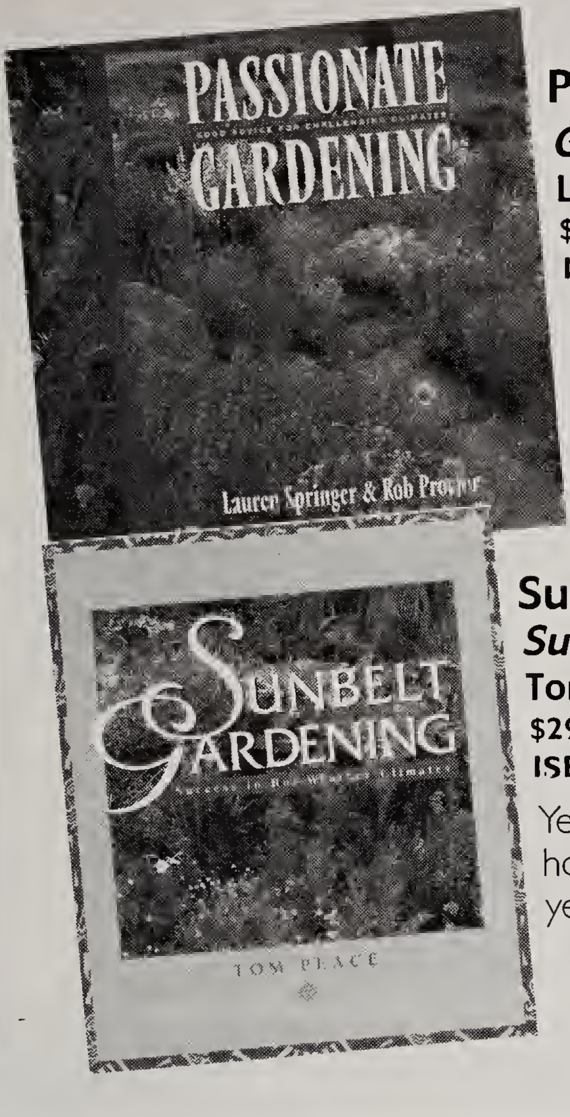

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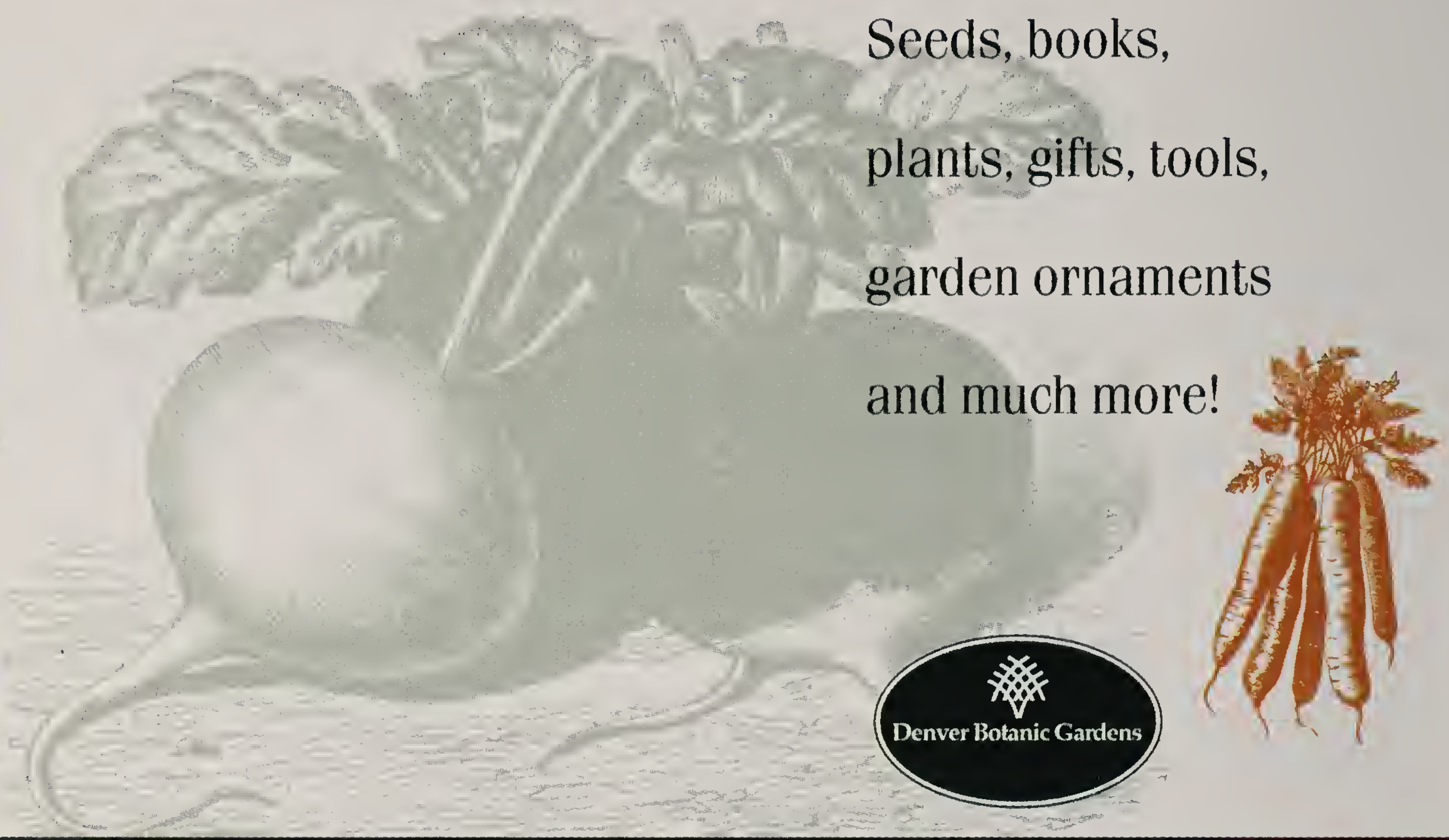

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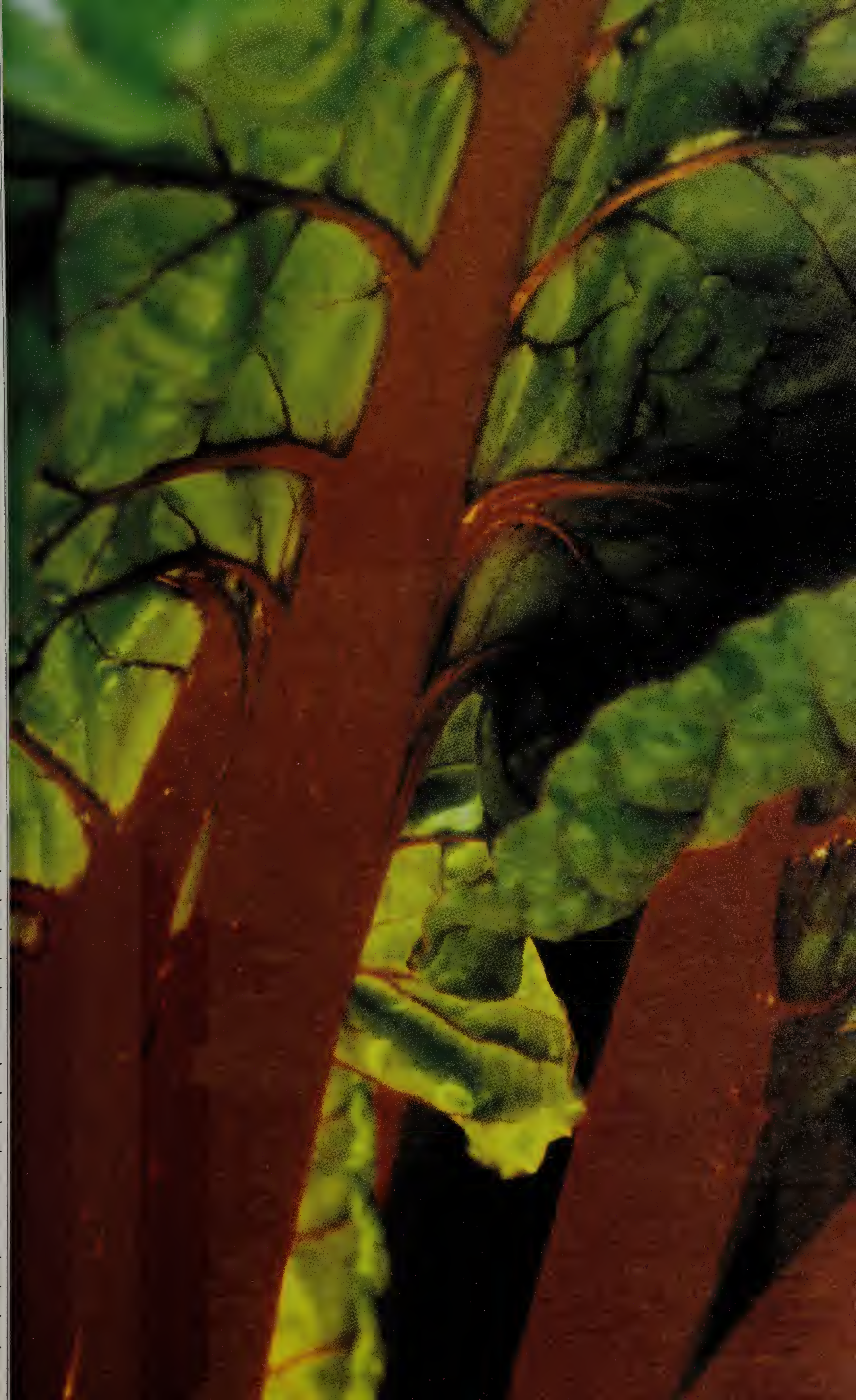

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